





505.73
V81

VOL. 30, NO. 1
SPRING 1979



IRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware
Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer
Box 637
Lancaster, Virginia 22503

SECTION EDITORS

Agricultural Sciences

R. J. Stipes
417A Price Hall
VPI & SU
Blacksburg, Va. 24061

Astron., Math. & Physics

Samuel P. Bowen
Dept. of Physics
VPI & SU
Blacksburg, Va. 24061

Biology

Patrick F. Scanlon
Dept. of Fisheries & Wildlife
VPI & SU
Blacksburg, Va. 24061

Botany

David A. Breil
Dept. of Natural Sciences
Longwood College
Farmville, Va. 23901

Chemistry

Robert G. Bass
Dept. of Chemistry
Va. Commonwealth Univ.
Richmond, Va. 23284

Education

C. Dillard Haley
Dept. of Education
900 Fairfax St.
Radford, Va. 24141

Engineering

Walter R. Hibbard
301 Holden Hall
VPI & SU
Blacksburg, Va. 24061

Environmental Sciences

Michael Garstang
Dept. of Env. Science
Univ. of Virginia
Charlottesville, Va. 22904

Geology

Roddy V. Amenta
Dept. of Geology
James Madison Univ.
Harrisonburg, Va. 22801

Materials Science

John C. Duke, Jr.
Dept. of Eng. Sci. & Mechanics
VPI & SU
Blacksburg, Va. 24061

Medical Sciences

Charles O'Neill
Dept. of Biophysics
MCV
Richmond, Va. 23298

Microbiology

Paul V. Phibbs, Jr.
Dept. of Microbiology
MCV-VCU
Richmond, Va. 23298

Psychology

Frank S. Murray
Psychology Dept.
Randolph-Macon Women's College
Lynchburg, Va. 24503

Space Science & Technology

Sam S. Fisher
Dept. of Mechanical and Aero-Space
Engineering
Thorton Hall, Univ. of Va.
Charlottesville, Va. 22901

Statistics

J. Van Bowen, Jr.
Dept. of Mathematics
Univ. of Richmond
Richmond, Va. 23172

©Copyright, 1979 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P.O. 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1979: \$15.00 per year, U.S.A.; \$20.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$4.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send *address changes* to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to the **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper ($8\frac{1}{2} \times 11$ inches). Margins should be not less than $1\frac{1}{4}$ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and

affiliation, and proposed running title, all appearing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year-format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first and last page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. *Metamorphic Textures*. Pergamon Press, New York. 350 pp.

Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians, Part III, Vertebrates* (Perry C. Hold, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 30

No. 1

Spring 1979

TABLE OF CONTENTS

EDITORIAL

ARTICLES

- Distribution and Nature of Carolina Bays on the Eastern Shore of Virginia. *D. E. Pettry, J. H. Scott, Jr., and D. J. Bliley.* 3
- The Effect of a Thermal Discharge on the Benthos of a Virginia Creek. *Donald K. Gartman, and Robert W. Lake.* 10
- Forests of Small Stream Bottoms in the Peninsula of Virginia. *Susan Glascock and Stewart Ware.* 17
- More Oribatid Mites in the Vicinity of Mountain Lake Biological Station, Virginia (Acari-formes: Oribatida). *Howard C. Sengbusch.* 22

EDITORIAL

This first issue of the 1979 volume of the Virginia Journal of Science comes with a new editor, a new printer, a new format, and over a year late. During 1980 we will make a strong effort to print 8 issues, bringing the Journal back up to date. This can be done, however, only with the vigorous support of the membership.

We urge members to give the Journal serious consideration as the place of publication of their and their students' research reports. We urge authors to submit manuscripts that are carefully written and typed, with figures and tables well-organized and neatly prepared, so that review time and revision time can be cut to a minimum. We ask that reviewers do their work as quickly as possible after receiving manuscripts, and that authors revise reviewed manuscripts as quickly as possible. All this will reduce turnover time and allows us to have enough high quality manuscripts to turn out issues at high frequency during 1980.

Under the vigorous leadership of Business Manager, Frank Kizer, the Journal has resumed its policy of carrying advertising. We hope members will take note of our advertisers and respond positively to this gesture of support on their part. If our business members, or officers of non-member businesses would be at all interested in supporting the Academy and its Journal through advertising, we urge you to let our business manager know of this interest, and he'll contact you about details.

We reiterate: our greatest immediate need is good manuscripts. Read our instructions to contributors and let us hear from you.

Distribution and Nature of Carolina Bays on the Eastern Shore of Virginia

D. E. Pettry, J. H. Scott, Jr.¹ and D. J. Bliley²

Department of Agronomy
Mississippi State University
Mississippi State, MS 39762

Abstract—Carolina bays are prominent geomorphic features of the Eastern Shore of Virginia. These land forms occur from sea level to the highest elevations on the peninsula. Most bays are located along the central part of the mainland. Bays appear to be surface features which are underlain by similar sand strata at depths of 2 to 4 m. The occurrence of bays on Pleistocene terraces of different elevations suggests multiple periods of bay formation. Tidal march encroachment into Carolina bays indicates they are relic landscape features.

Introduction

Carolina bays were noted on Virginia's Eastern Shore in an early soil survey (USDA, 1920), which reported the level topography is broken by low ridges that enclose basin-like depressions. These basins have also been referred to on the Eastern Shore as whale wallows and Maryland Basins (USDA, 1970). Carolina bays are wet, shallow elliptical depressions with a parallel orientation in a NW-SE direction. They occur along the Atlantic Coastal Plain from Florida to New Jersey with estimates of perhaps a half million such features (Prouty, 1952).

Theories of Bay Origin—One of the earliest reported scientific works to draw attention to these peculiar basin-like depressions concerned bays in South Carolina (Toumey, 1848). He suggested the bays were formed by the action of springs rising to the surface of a sandy plain. Later work advocated an origin due to the actions of winds and waves on sand bars of shallow coastal embayments producing depressions enclosed by sand ripples (Glenn, 1895).

The term "Carolina bay" apparently was proposed in 1933 to refer to the oval or elliptical bays enclosed by low sandy ridges (Melton and Schreiever, 1933). The term originated because the depressions were first studied in the Carolinas where they were noted to widely occur, and because the basins commonly contain bay trees (Frey, 1949). Later publications proposed the term Neptune rings to describe the unusual depressions (Cooke, 1945), but Carolina bays apparently was the preferred description of the scientific community.

World attention was attracted to the subject when Melton and Schreiever (1933) proposed a meteoritic

origin for Carolina bays. These workers proposed the bays were formed by the infall of meteorites of a probable cometary mass travelling in a southeast direction and hitting the earth at a low angle to the horizontal. Contrasting theories concerning the origin of the bays were proposed by C. W. Cooke (1933) who interjected new ideas into the controversy. Cooke proposed that bays are formed through construction of crescentic keys and segmented lagoons via forces of a dominant southeast wind. He proposed the wind created elliptical currents that scooped out elliptical depressions with the long axis parallel to the direction of the wind. Melton (1934) contested the views of Cooke. He proposed that if the meteoritic theory was untenable, his next choice was bay formation by submarine scour resulting from eddies, currents or undertow. MacCarthy (1937) reported Carolina bays were formed by the shock-waves accompanying a shower of large meteorites upon the earth. He further stated that bays are much larger than the meteorites that produced them. Later, Cooke (1940, 1954) proposed a new theory stating that bays were created in any confined body of water by the formation of elliptical eddies directed through gyroscopic effects of the earth's rotation.

Other interesting theories to account for the origin of Carolina bays developed in the decades of the 1930's through the 1950's. Johnson (1936) purported that Carolina bays are essentially the product, either directly or indirectly of solution, and the encircling rims represent accumulations of wind drift sand. Later, he proposed a new theory of bay origin that included the upwelling of artesian springs in association with ground water to produce circular rims (Johnson, 1942). A unique theory also involving artesian springs was advanced by Grant (1945), who proposed that hovering activities of spawning schools of fish are responsible for the formation of the shallow sand-rimmed depressions. Supposedly, such activities occur where artesian springs of fresh water appear in near-shore marine areas.

Thom (1970) reported a relationship between bay size and shape, and the size of the undissected Coastal Plain interfluvies. He postulated bay formation by the expansion of shallow water bodies influenced by strong unidirectional winds during the Wisconsin Glaciation. Studies in North Carolina (Bryant and

¹Present address: National Aeronautics and Space Administration, Wallops Flight Center, Wallops Island, Va. 23337

²Present address: Soil Conservation Service, Smithfield, N.C.
27577

McCracken, 1964) indicated that Carolina bays and associated inter-bay soils had similar parent materials, but bay soils were apparently younger. Recently, Gamble, Daniels and Wheeler (1977) reported many bays in North Carolina had secondary rims overlying a primary rim indicating more than one period of bay development.

A novel theory recently advanced to account for the formation of Carolina bays suggests they may be due to the impact of antimatter (Baxter and Atkins, 1978). It was suggested that minute scraps of antimatter striking the earth could leave impact features (bays) without any trace of the causal agent.

Few reports have been directed at Carolina bays on the Eastern Shore of Virginia. Cooke (1954) reported that Half Moon Bay and Island Bay in Accomack County resulted from the action of tidal eddy currents. He further stated that all known elliptical ridges in Virginia and Maryland lie below 2 m elevation. Sinnott (1953) reported numerous Carolina bays occurred along the peninsula. The present study was conducted from 1972-1975. It initiated as a part of a comprehensive research project in remote sensing in agriculture. The objectives of this study were to investigate Carolina bays using remote sensing imagery, and to determine their relationships to soils and local geomorphology.

Study Area

The study area is located in Accomack and Northampton Counties, Virginia (Fig. 1). Forming the lower part of the Delmarva Peninsula, these counties are commonly referred to as the Eastern Shore of Virginia. The area is bounded on the east and south by the Atlantic Ocean, on the west by Chesapeake Bay, and on the north by the state of Maryland. The counties comprise of land area about 1,767 km². The mean width of Accomack, the upper county, is about 12.9 km, and Northampton County has an average width of about 9.6 km. The two-county Virginia portion of the peninsula tends northeast-southwest and is about 120 km long.

The area consists of the mainland, the offshore barrier islands, and the salt marshes and lagoons. Few points exceed 17 m elevation above mean sea level. The drainage divide bisects the counties, diverting the drainage on the eastern side to the Atlantic Ocean, and on the western side to Chesapeake Bay. The principal drainage consists of tidal estuaries, locally called creeks. The mainland consists of a series of Pleistocene terraces. The Talbot terrace (7.5-13.5 m) comprises the central portion of the peninsula (Sinnott and Tibbitts, 1961). It is bordered by the lower Princess Anne (1.5-4.5 m) which includes elements of the Dismal Swamp terrace (4.5-7.5 m). Steam dissection has not affected large segments of these terraces.

Both counties lie within the Coastal Plain Province. The soils have developed in thick marine sediments. Gravimetric surveys indicate about 1,220 m of sediments overlie basement rock in the Exmore-Melfa



FIG. 1.—Location of study area and sampling sites.

area, and the thickness increases near Wallops Island (Johnson and Sweet, 1970).

Methods

Imagery—Photographic analyses were made of NASA infrared photography (June, 1971) covering the two-county area. Imagery was obtained from an RC-130 aircraft at 3646 m altitude using a Wilde RD-8 camera with a Wratten 12 × 2.2 AV filter and Kodak Aerochrome color infrared film. Positive transparencies were 22.5 × 22.5 cm with an approximate scale of 1:20,000. High altitude color infrared imagery taken at an altitude of 19,803 m aboard a NASA U-2 aircraft (January 1972) was also used in the study. A photointerpretative inventory of Carolina bays was made using a Richards light table.

Soils—A field survey was made of the mainland and selected offshore islands. Soil investigations were made on 40 Carolina bays located at elevations from sea level to 17 m with soil auger and pits using standard methods (USDA, 1951). Four bays were sampled for laboratory analysis. Soil particle size distribution was determined by the pipette method (Day, 1965) and coarse fragments (>2 mm) by sieving. The clay fraction was separated and analyzed by X-ray diffraction according to the methods of Jackson (1956). A General Electric XRD-5 X-ray instrument was used with Cu K α radiation generated at 40 kv, 20 mA and a scanning speed of 2° per minute.

Soil pH was determined in a 1:2 soil-solution mixture with a Sargent Model DR pH meter. Organic

matter was determined by the method of Peech and others (1947). Exchangeable acidity was determined by the barium chloride-triethanolamine method (Peech, 1965) and exchangeable aluminum was determined following the procedure of Yuan (1959). Exchangeable cations were extracted with NH_4OAc at pH 7 (Chapman, 1965) and determined with the Perkin-Elmer Model 303 atomic absorption spectrophotometer.

Results and Discussion

Over 150 landscape features were identified by imagery evaluations and classified as Carolina bays following field investigations. The basin-like depressions occurred from the lower salt marshes to the higher elevations of the mainland. Bays were most numerous on the higher central terraces and they had a similar orientation. The bays ranged in shape from circular to ellipsoidal, and in size from about 150 m to 1.6 km. In a related study Bliley (1974) determined the bays had a mean orientation of 299° and he suggested these may be more rounded than bays reported in the Carolinas. In places, bays occurred in clusters, often bounding or overlapping each other. Bays with multiple and incomplete rims were common.

The outer rims ranged from 1 to 4 m higher than the central basins. The rims have lighter colored tonal patterns that contrast with the darker, wetter bay centers which enhances photographic detection (Fig. 2). Although surface drainage patterns and wet soils occurred adjacent to many of the bays, they could be readily delineated. However, bays located entirely in densely wooded areas of uniform vegetation were very difficult to recognize, and stereoscopic coverage was useful in detecting the elevated rims.

Marked vegetation differences were associated with the Carolina bays located in the marshes near sea level.



FIG 2—Carolina bay at higher elevation with light colored rim and dark center (infrared imagery).

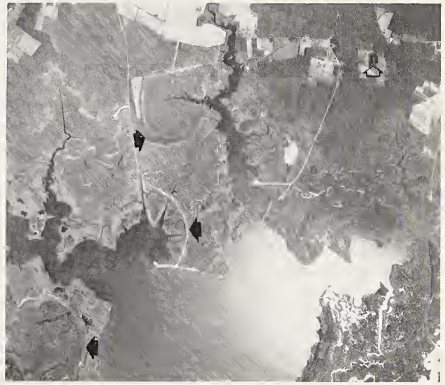


FIG 3—Carolina bays located in the tidal marsh near Guard Shore showing partial bays and road located on the rim of a bay (infrared imagery).

Woody vegetation, including pine trees, commonly occur on the higher, better drained rims of bays in contrast to the wet tidal marsh bay centers (Fig. 3). These vegetative differences are readily detected on the color infrared photographs.

Although the larger bays could still be detected on the infrared imagery taken at 19,803 m (Fig. 4), many



FIG 4—Image of the southern portion of the Eastern Shore obtained via U-2 aircraft (infrared imagery) showing Carolina bays (Approximate Scale 1:37, 150).

of the smaller bays could not be identified without considerable magnification. The panoramic view produced by the high altitude imagery is conducive to delineate the occurrence pattern of the bays. It was difficult to detect bays on ERTS satellite imagery obtained from 886 km in space.

Soils—Pedological differences exist between soils of Carolina bays at higher elevations and those located near sea level. The rims of mainland bays had well-drained soils with centers of somewhat poorly and poorly drained soils. During field studies in the spring of 1973, the ground water table of rim soils was not detected within 175 cm of the surface, whereas it occurred in the upper 50 cm of soils comprising the interior part of the bays. Generally, rim soils exhibited greater pedogenic development than centers as reflected by brighter colors, clay movement-accumulation and distinct horizonation. Soils in bay centers were darker colored and contained higher silt and organic matter content than rim soils.

In contrast, soil comprising the rims of bays near sea level had must less pedogenic development and horizonation. Soils were stratified and undifferentiated in the bay centers with mucky surfaces and high silt contents indicating recent deposition. The water table was encountered at depths of 75 to 125 cm in the rim soils. The bay centers are flooded at high tide and appear to be continuously saturated. Soil development in bays near sea level indicate much younger soils as evidenced by pedogenic features.

Coarse fragments were absent in the bay soils examined except for bays in the coastal marsh near Guard Shore (Table 1). These coarse fragments were smooth, rounded quartz pebbles ranging from 2mm up to 5 cm in diameter. Bay rims contained more sand and less silt than centers indicating greater depositional energy.

Both rims and centers had sandy textures at depths greater than 2 to 3 m, as did adjacent soils. A yellowish-brown to gray sandy stratum was observed under all bays examined in both counties.

Bay soils at higher elevations were acid, except where heavily limed, in contrast to bay soils near sea level which were neutral reflecting the salt water influence. The mainland bay soils were very low in extractable bases (Table 2) in comparison to those near sea level. Low levels of exchangeable aluminum were detected in rim and depression soils.

The clay fractions of rim and depression soils at higher elevations consist of kaolinite, vermiculite-chlorite integrade, quartz, and minor amounts of mica and gibbsite. Bays near sea level had clay fractions consisting of kaolinite, vermiculite, mica, vermiculite-chlorite integrade and quartz with significant amounts of montmorillonite in subsoils of the bay centers. The mineral content was more variable in the lower-lying bays. Greater gibbsite contents were detected in the lower horizons of bay rim and depression soils at higher elevations. Gibbsite is often associated with older weathered soils or intense weathering. The montmorillonite in centers of bays near sea level may be recent deposition of Chesapeake Bay sediments. The sand and silt fractions of bay rims and depressions were dominated by quartz with trace amounts of feldspars and mica.

Land Use—Interesting land use practices appear to be associated with the Carolina bays. In the lower coastal marsh areas the higher rims are utilized as parts of roads (Fig. 3). Cemeteries and buildings were also constructed on the rims throughout the peninsula (Fig. 5). Lack of natural drainage in the oval depressions was remedied in cultivated areas by ditches and excavations through the surrounding rims to an outlet. The

Table 1. Particle size distribution of representative rim and depression soils of selected Carolina bays at different elevations on the Eastern Shore. Samples were taken from the top center of the rims and the center of the depressions.

Elevation m	Depth cm	Coarse Fragments (>2 mm) %		Sand (2-.05 mm) %		Silt (.05-.002 mm) %		Clay (<.002 mm) %	
		Rim	Depression	Rim	Depression	Rim	Depression	Rim	Depression
15 (Nelsonia)	0-20	-	-	61.7	61.2	27.6	25.9	9.7	12.8
	125-150	-	-	84.3	47.6	5.6	30.4	10.2	21.9
	250-275	-	-	>95	>95	-	-	-	-
12 (Eastville)	0-20	-	-	71.9	60.1	21.9	29.9	5.8	10.0
	125-150	-	-	71.8	73.6	17.7	14.5	10.5	11.8
	250-275	-	-	>95	>95	-	-	-	-
10 (Bell Haven)	0-20	0.9	-	82.7	58.8	13.0	30.4	4.2	10.7
	60-80	-	-	77.2	69.3	12.7	28.9	10.1	1.7
	125-150	-	-	97.9	92.7	1.4	2.7	0.9	4.5
	250-275	-	-	>95	>95	-	-	-	-
2 (Guard Shore)	0-20	7.1	1.0	70.6	20.5	23.9	47.0	5.5	32.4
	125-150	17.5	6.3	65.2	16.2	19.6	58.9	15.1	24.8
	250-275	-	-	>95	-	-	-	-	-

Table 2. Chemical characteristics of representative rim and depression soils of selected Carolina bays at different elevations on the Eastern Shore.

Elevation m	Depth cm	pH	Organic Matter %	Exchangeable Cations meq/100g				Extractable Acidity meq/100g
				Ca	Mg	K	AL	
Rim Soils								
10 (Nelsonia)	0-20	5.3	0.4	0.31	0.01	0.03	0.04	3.38
	50-60	5.5	0.1	1.45	0.28	0.10	0.09	2.34
	125-150	6.6	-	0.17	0.02	0.01	-	0.94
12 (Eastville)	0-20	6.6	0.3	1.45	0.70	0.44	-	3.21
	125-150	6.4	-	1.95	0.40	0.10	-	2.69
2 (Guard Shore)	0-20	4.6	0.7	0.10	0.72	0.28	0.52	5.47
	125-150	5.1	-	1.65	2.24	0.23	0.50	4.08
Depression Soils								
10	0-20	4.7	1.2	0.17	0.02	0.13	1.80	11.70
	50-60	4.8	0.1	0.60	0.11	0.11	1.30	4.18
	125-150	4.9	0.1	0.12	0.01	0.03	0.03	2.34
12	0-20	6.1	0.9	0.72	0.42	0.10	0.80	2.21
	125-150	4.8	0.1	0.64	0.23	0.11	1.20	3.56
2	0-20	6.9	11.2	4.00	29.00	3.75	0.17	15.01
	125-150	6.8	0.2	1.20	4.00	0.50	-	2.86

droughty nature of the higher sandy rims often necessitates different agronomic practices. Intensive mechanized cultivation appears to be gradually leveling the rims and filling the bay centers, thus making them more difficult to recognize (Fig. 6).

Carolina bays on the Eastern Shore seem to be stable except for erosion due to cultivation and cultural activ-

ities and erosion by tidal waters. The presence of old cemeteries and buildings over a century old on rims support this premise. Topographic bench marks and aerial photographs also indicate the stability of bays over the past three decades.



FIG 5—Cemetery located on higher, well drained rim of a Carolina bay with road cutting through the rim.



FIG 6—Cultivation across center and rim of Carolina bay as seen looking from the outside due South over the rim toward the center. Potato rows are about 1 m apart. Rims are gradually being worn down by intensive cultivation.

Bays and Geomorphology—Carolina bays occur on the Eastern Shore in a definitive pattern (Fig. 1). A majority of bays are on the Talbot terrace along the central portion of the peninsula. Many bays occur on the narrow segment of the Princess Anne terrace (Fig. 1, inset A). Groups of bays are located in the northwestern part of the study area in tidal marshes along Chesapeake Bay (Fig. 1, inset B). This area contains the largest bays although many of them do not have complete rims.

More bays were detected in Accomack than in Northampton County. The Talbot surface is wider in Accomack County and presented a larger stable land surface for bay development. The size of the terrace surface appears to have an influence on the extent and size of the bays. Eleven bays were identified on Bradford Neck between Wachapreague and Quinby and three bays on Upshur Neck south of Quinby. Bradford and Upshur Necks are narrow necks separated from the eastern mainland by tidal streams and bounded on the east by recent tidal marshes and lagoons. The bays are small and in proportion to the narrowness of the land surface. The western ends of these bays have been truncated by the Machipongo River or other streams.

About 25 partial bays were identified in the tidal marshes of Chesapeake Bay between Deep Creek and Sanford. Many of these bays have a crescent shape with incomplete rims. The rims are sandy and contain more woody vegetation than the tidal marsh centers and surrounding area. The marsh sediments are silty and contain large amounts of organic matter. The marsh appears to be breaching the pre-existing bay rims and gradually destroying or inundating them. The marshes are apparently recent and developing in response to rises in sea level (Oaks and Coch, 1963). The isolated bay rims surrounded by tidal marsh represent older land surfaces related to higher energy depositional levels than are present in the present marsh environment.

Carolina bays are conspicuously absent along the eastern Atlantic barrier islands and associated marshes and lagoons. However, this is expected because the barrier islands are dynamic Holocene land-forms. Presumably, any pre-existing bay landforms would have been masked or obliterated by the present dynamic off-shore islands and marsh. It is also envisioned that a suitable, stable landform would be necessary for a considerable time period for bay development. No evidence was observed that would indicate Carolina bays are currently forming in the sandy coastal plain Holocene (recent) sediments.

Summary

In contrast to earlier reports (Cooke, 1954), this study shows that Carolina bays occur on the Eastern Shore from sea level to the highest elevations. They are prominent geomorphic features. Most bays occur on the higher elevations along the Central part of the mainland. Carolina bays in the study area are less elliptical than bays reported in North and South Carolina.

The absence of detectable contiguous calcareous strata near the surface and the great sediment thickness over basement rock tend to discount earlier solution theories of bay formation. Our physical, chemical and mineralogical data were limited to shallow depths, but no evidence of a meteoric bay origin was detected. The presence of bays at various elevations on different stratigraphic units strongly suggests different periods of bay formation. The occurrence of bays below a scarp near Wachapreague indicates they are younger than bays at higher elevations. Brighter soil colors and greater pedogenic development in bays at higher elevations also suggest they are older.

Current bay destruction by marsh encroachment and lack of evidence for current bay formation indicate they are relic landscape features. The presence of similar sand strata at depths of 2 to 4 m underlying bays at different elevations suggests they are surface features. The higher sandy rims have a "dune-like" appearance which are suggestive of wind action.

Carolina bays on the Eastern Shore appear to have formed in sandy surficial sediments of larger terraces that were stable and undissected for a considerable time period.

Acknowledgements

This research was conducted at the Department of Agronomy, Virginia Polytechnic Institute and State University. Supported in part by the National Aeronautics and Space Administration, Wallops Flight Center, Va. (NASA Contract NAS 6-1863).

Literature Cited

- Baxter, J. and Atkins, T. (1978): *The Fire Came By*. Readers Digest 12, 217-253.
- Bliley, D. J. (1974): *Soils and Morphology of Carolina Bays*, Eastern Shore, Virginia. M.S. Thesis. Blacksburg, Va.
- Bryant, J. P. and McCracken, R. J. (1964): Properties of Soils and Sediments of Carolina Bays. *J. Elisha Mitchell Sci. Soc.* 80, 166.
- Chapman, H. D. (1965): Total Exchangeable Bases. *In* *Methods of Soil Analysis*, Part 2 (C. A. Black, ed.), Chap. 58, pp. 901-904. Amer. Soc. of Agron., Madison, Wisconsin.
- Cooke, C. W. (1933): Origin of the So-called Meteorite Scars of South Carolina. *Washington Acad. Sci. J.* 23, 569-570.
- Cooke, C. W. (1940): Elliptical Bays in South Carolina and the Shape of Eddies. *J. Geol.* 48(2), 205-211.
- Cooke, C. W. (1945): Neptunes Elliptical Bays. *J. Geol.* 51, 419-427.
- Cook, C. W. (1954): Carolina Bays and the Shapes of Eddies. *U. S. Geol. Survey Prof. Paper* 254-1, 195-201.
- Day, P. R. (1965): Particle Fractionation and particle Size Analysis. *In* *Methods of Soil Analysis* (C. A. Black, ed.), Chap. 43, pp. 545-567. Amer. Soc. of Agron., Madison, Wisconsin.
- Frey, D. G. (1949): Morphometry and Hydrography of Some Natural Lakes of the North Carolina Coastal Plain. *J. Elisha Mitchell Sci. Soc.* 65(1), 1-37.
- Gamble, E. E., Daniels, R. B. and Wheeler, W. H. (1977): Primary and Secondary Rims of Carolina Bays. *Southeastern Geol.* 18, 199-212.
- Glenn, L. C. (1895): Some Darlington South Carolina Bays. *Science* 11, 472-475.
- Grant, C. (1945): A Biological Explanation of the Carolina Bays. *Sci. Monthly* 61(6), 443-450.

- Jackson, M. L. (1956): Soil Chemical Analysis, pp. 169-252. University of Wisconsin, Madison, Wisconsin.
- Johnson, D. W. (1936): Origin of the Supposed Meteorite Scars of Carolina. *Science* 84, 15-18.
- Johnson, D. W. (1942): Origin of the Carolina Bays. 341pp. Columbia Univ. Press.
- Johnson, S. S. and Sweet, P. C. (1970): Gravity Survey of Northampton and Accomack Counties, Virginia. *Va. Minerals* 16(3) 21-27.
- McCarthy, G. R. (1937): The Carolina Bays. *Geol. Soc. Amer. Bull.* 48, 1211-1226.
- Melton, F. A. and W. Schriever (1933): The Carolina Bays. *J. Geol.* 41, 52-66.
- Melton, F. A. (1934): The Origin of the Supposed Meteor. scars. *J. Geol.* 42, 97-104.
- Oaks, R. Q. and N. K. Coch (1963): Pleistocene Sea Levels, southeastern Virginia. *Science* 140, 979-983.
- Peech, M., Alexander, L. T., Dean, L. A., and Reed, J. F. (1947): Methods of Soil Analysis for Soil-fertility Investigations. USDA Circ. 757. Washington, D.C.
- Peech, M. (1965): Exchange Acidity. *In* Methods of Soil analysis (C. A. Black, ed.), Chap. 60, pp. 914-926. Amer. Soc. of Agron., Madison, Wisconsin.
- Prouty, W. F. (1952): Carolina Bays and Their Origin. *Geol. Soc. Amer. Bull.* 63(2), 167-224.
- Sinnott, A. (1953): Carolina Bays on the Coastal Plain of Virginia. *Va. J. Sci.* 4(4), 258.
- Sinnott, A. and Tibbitts, G. C. (1961): Pleistocene Terraces on the Eastern Shore of Virginia. *U. S. Geol. Survey* 424-D, 248-250.
- Thom, B. G. (1970): Carolina Bays in Horry and Marion Counties, South Carolina. *Geol. Soc. Amer. Bull.* 81(3), 783-813.
- Tourmey, M. (1848): Report on the Geology of South Carolina. *Geol. Survey South Carolina*, 143-144, Columbia, S. C.
- USDA Soil Survey Staff (1920): Soil Survey of Accomack and Northampton Counties, Virginia, p. 7. U.S. Government Printing Office, Washington, D.C.
- USDA Soil Survey Staff (1951): Soil Survey Manual, pp. 123-145. U. S. Government Printing Office, Washington, D.C.
- USDA Soil Survey Staff (1970): Soil Survey of Wicomico County, Maryland, p. 83. U. S. Government Printing Office, Washington, D.C.
- Yuan, T. L. (1959): Determination of Exchangeable Hydrogen in Soils by a Titration Method. *Soil Sci.* 88, 164-167.

The Effect of a Thermal Discharge on the Benthos of a Virginia Creek

Donald K. Gartman

Columbia Gas System Service Corporation
Environmental Affairs Department
20 Montchanin Road
Wilmington, Delaware 19807

and

Robert W. Lake

Associate Scientist
Department of Entomology and Applied Ecology
University of Delaware
Newark, DE 19711

Abstract—The Columbia Gas Transmission Corporation, Gala Compressor Station has been using water from Mill Creek in Botetourt County, Virginia, to cool the compressor engines since 1940 at an estimated rate of 1.3×10^2 cms to 6.6×10^2 cm. A May-October (1976) investigation of the benthic communities and the thermal regime of Mill Creek indicated the following: Stream discharge ranged from 1.12×10^1 cms to 2.76 cms while cooling water use ranged from 1.68×10^2 cms to 4.8×10^2 cms. A total of 74 genera of benthic macroinvertebrates was collected during the course of this study. Forty-eight taxa were recorded from the downstream-pool-stations, 43 from upstream-pool-stations, 49 from downstream-riffle-stations, and 57 from upstream-riffle-stations. Mean downstream benthic densities ranged from 473/m² to 5371/m² while mean upstream benthic densities ranged from 204/m² to 2938/m². Mean downstream benthic taxa ranged from 3 to 12 while mean upstream benthic taxa ranged from 2 to 16. Mean downstream diversity (*d*) estimates ranged from 1.157 to 2.421 while mean upstream diversity (*d*) estimates ranged from 0.549 to 3.254. Differences were not significant (*p* = .05). The greatest increases in stream temperature were recorded July 27 and August 31 when a 4.9 and a 10.1°C, respectively, difference existed between ambient upstream temperature and the riffle transect 15m downstream from the discharge. The high stream discharge of the October sampling effectively "scoured" the stream bottom and resulted in very low benthic densities at all sampling stations.

Introduction

There have been many large scale studies in recent years to monitor the effects of heated-water discharges to major waterbodies (Coutant and Talmadge, 1977). Also, two bibliographies, Kennedy and Mihursky (1968) and Raney *et al.* (1973) are available which review the effects of heated discharges on aquatic organisms. Most thermal impact studies in the past have dealt with relatively large projects, i.e., thermal discharges from nuclear power plants to rivers, lakes, or estuaries. One of the most recent and rigorous investigations of such a project is The Connecticut River

Ecological Study, The Impact of a Nuclear Power Plant (Merriman and Thorpe, 1976). In this study, cooling water use was 23.5 cms, while the river had a monthly discharge of 333 cms. Studies of small scale thermal discharges are usually limited to laboratory designs in highly artificial (as well as highly controlled) situations. A relatively limited heated-water discharge to a small Virginia stream presented the opportunity to monitor the response of the benthic community in the vicinity of this effluent.

The Columbia Gas Transmission Corporation, Gala Compressor Station has been using water from the adjacent Mill Creek in Botetourt County, Virginia, to cool compressor engines since the facility was constructed in 1940. Cooling water use ranges from 1.3×10^2 cms 6.6×10^2 cms. Water temperatures of the cooling water are increased and discharged back into Mill Creek approximately 46 m downstream from the intake source. Water temperatures at the discharge pipe range between 27 and 54°C. Discharge rate is estimated to average less than 2.8×10^2 cms. The discharged water falls approximately one meter into a rock-lined channel which parallels the stream and enters Mill Creek from the north bank. The thermal plume is generally restricted to the north bank for the first 15 m until the first major riffle is approached, where the water masses begin to mix.

Study Area

Mill Creek is a tributary of the James River with headwaters in the Jefferson National Forest near the Botetourt-Rockbridge County line (Fig. 1). It is a second-order stream with a gradient of approximately 10.0 m/km in the vicinity of the study area. The chan-

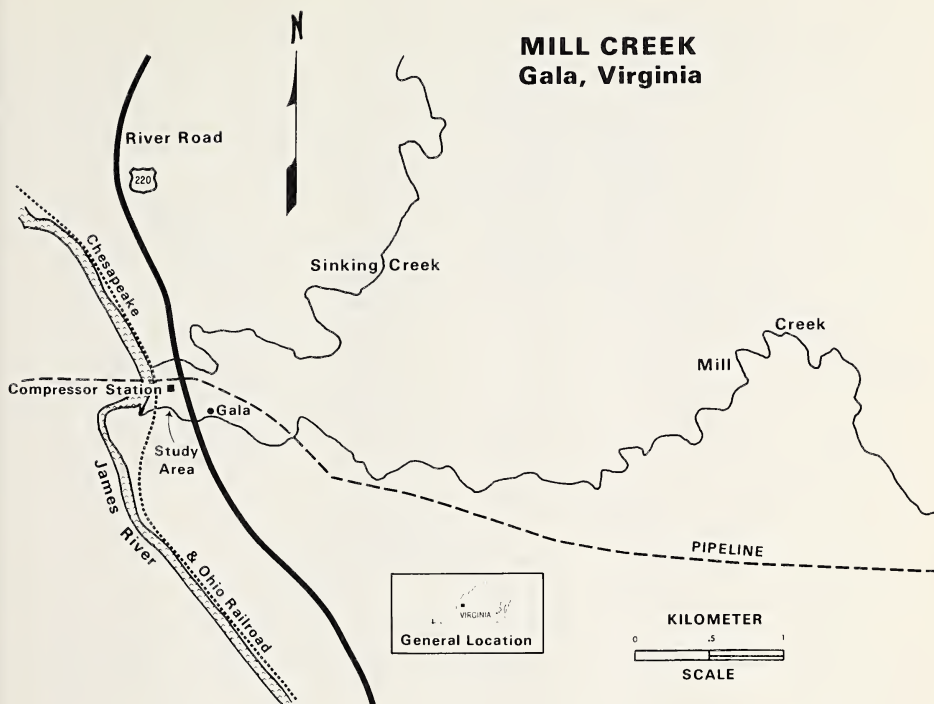


FIG. 1—Map of study area, general location.

nel width within the study area ranges between 9.8 and 5.0 m with an average depth of 0.2 m. Substrate consists of boulders, cobbles, and sand with very little silt and detritus except in quiet pools at bridges. The study site consists of a series of long riffles and shallow pools. Stream discharge ranges between 1.13×10^3 and 2.76 cms as estimated by the floatation method of Robins and Crawford (1954).

Stream border vegetation is dominated by sycamore (*Platanus occidentalis*), river birch (*Betula nigra*), willow (*Salix* sp.), alder (*Alnus* sp.), honeysuckle (*Lonicera japonica*), and assorted perennials.

Methods

Four transects were established at the study site: one "riffle" transect approximately 15 m downstream and one "pool" transect approximately 7.5 m downstream from the heated discharge with a "riffle" and a "pool" transect at approximately equal distances upstream from the heated discharge for "control" samples (Fig. 2). One Surber (1024 μ net mesh) sample was taken at two shore and one mid-stream station along each transect once each month from May 1976 through October

1976. Samples were fixed in 70% ethanol for subsequent identification and enumeration. Water temperatures were recorded at each benthos sampling station. Stream discharge was estimated by the floatation method of Robins and Crawford (1954).

Stream temperatures were recorded with a Digimite Temperature Indicator Model 31160-2-4-0313, Thermo-Electric Co., Saddlebrook, New Jersey. Surface and bottom temperatures were measured, beginning at the input source and continuing at 0.3 m intervals downstream to determine the length of the plume. Temperature profiles were also measured at 0.3 m intervals transversely on transects located 1.5 m apart to describe the width of the thermal plume. Temperatures were recorded downstream until the 1°C above-ambient upstream temperature was recorded.

Stream temperatures at the mouth of Mill Creek (approximately 259 m downstream from the discharge point) and within the James River were also recorded at each sampling period. Ambient upstream temperatures were recorded several times during the thermal data collection to compensate for natural daily rises in stream temperatures during the monitoring interval.

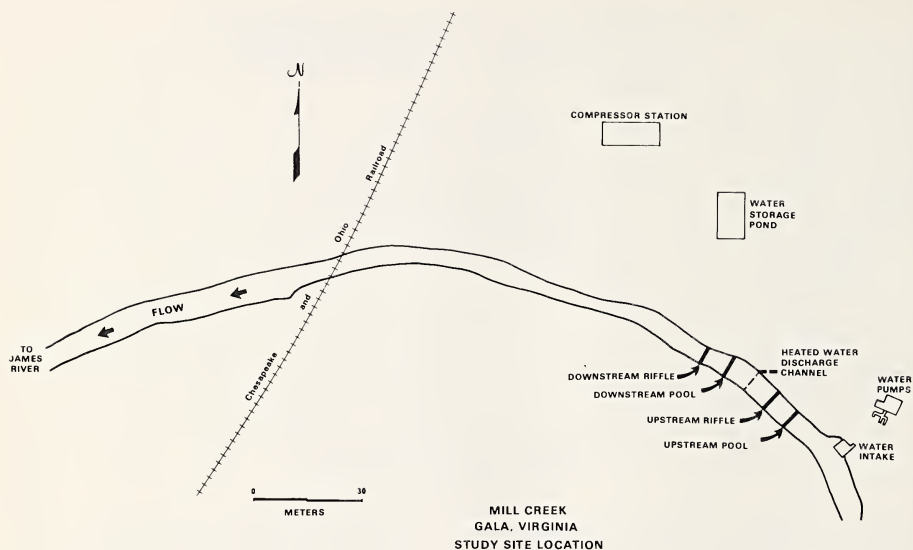


FIG 2—Study site transect locations.

TABLE I

Water Temperatures of Mill Creek and Study Transects
(7.5 and 15 m downstream from heated discharge), Gala
Virginia, Botetourt County, 1976

Date	\bar{x} Upstream Temperature (°C)	\bar{x} Downstream (°C) Pool	\bar{x} Downstream (°C) Riffle	Max. Δt (°C)	Stream Discharge (cms)
May 26, 1976	15.8	18.7	18.3	2.9	0.36
June 29, 1976	20.1	20.6	20.1	0.5	0.62
July 27, 1976	22.2	27.1	26.5	4.9	0.16
August 31, 1976	16.2	26.3	25.2	10.1	0.11
September 28, 1976	17.8	19.3	19.3	1.5	0.15
October 27, 1976	7.8	7.8	7.8	0.0	2.76

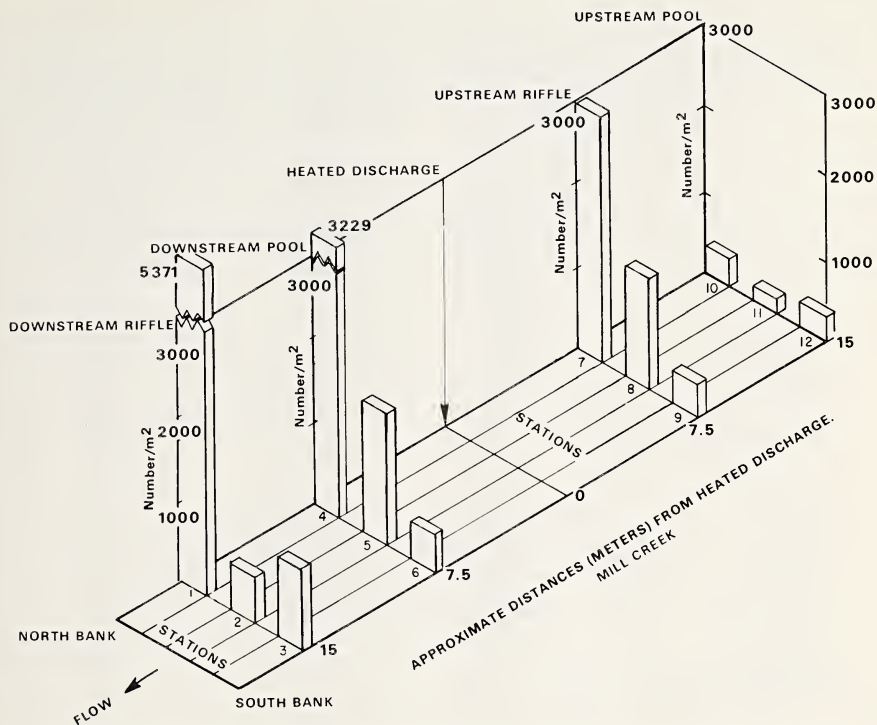


FIG. 3. Mean numbers of benthic organisms per square meter at stations above and below heated discharge, Mill Creek, Botetourt County, Virginia, May-October 1976.

Results and Discussion

Table 1 summarizes the upstream Mill Creek temperatures relative to the downstream pool and riffle transects. It can be seen that the dates of July 27 and August 31 indicate 4.9°C and 10.1°C increases above ambient upstream temperatures, respectively.

A total of 74 genera of benthic macroinvertebrates was collected during the course of this study. Insects accounted for 60, mollusks 6, crustaceans 2, nematodes 1, oligochaete worms 2, hydra 1, horsehair worms 1, and planaria 1. Forty-eight taxa were recorded from the downstream-pool-stations, 43 from the upstream-pool-stations, 49 from the downstream-riffle-stations, and 57 from the upstream-riffle-stations.

Fig. 3 presents the mean numbers of benthic organisms collected per square meter at stations above and below the heated discharge for the study period May-October, 1976. Mean benthic densities ranged from 473/m² to 5371/m² at downstream stations and 204/m² to 2938/m² at upstream stations.

Five orders of invertebrates comprised more than 97% of the total specimens collected: Plesiopora (Oligochaeta) 58.1%, Ephemeroptera 14.8%, Diptera 13.8%, Trichoptera 9.0%, and Coleoptera 2.2%. Table 11 lists the twenty most common invertebrates and compares the numbers between upstream and downstream sampling stations. Numbers of *Pseudocloeon* were four times greater at the downstream sampling stations. However, more than half of these were collected in the May sample before any great changes in water temperatures were evident. *Hexagenia*, (a burrowing mayfly) was found at one downstream station once, and none was recorded at an upstream station. *Stenonema*, *Isonychia*, and *Caenis* were the genera occurring in significant numbers. Oligochaeta were represented in over 79% of the samples but were much more abundant downstream with the majority being members of the family Tubificidae.

In the dipteran genera, no great disparity in numbers was noted between the upstream and down-

TABLE II

Twenty Most Common Benthic Invertebrates Collected Per Six Surber Samples, Comparison of Upstream and Downstream Sampling Sites in Descending Order of Abundance Mill Creek, Gala, Virginia. May - October, 1976

Taxa	Downstream No. Specimens	Upstream No. Specimens	Total No. Specimens
Oligochaeta	5551	109	5660
Chironomidae	642	576	1218
Stenonema	33	613	646
Hydropsyche	103	294	397
Isonychia	32	231	263
Chimarra	1	170	171
Hydropsychidae ^a	19	129	148
Cheumatopsyche	3	113	116
Heptageniidae ^b	1	107	108
Pseudocloeon	87	20	107
Psephenus	28	78	106
Caenis	16	83	99
Leuctra	6	73	79
Ferrisia	45	27	72
Simulium	42	27	69
Optioservus	30	38	68
Epeorus	13	39	52
Ephemerella	29	18	47
Heptagenia	3	37	40
Paraleptophlebia	8	29	37

^aThis includes Cheumatopsyche and Hydropsyche. Individuals were too small to determine to genus.

^bThis includes both Heptagenia and Stenonema. Individuals were either too small to determine accurately to genus or gills were missing.

stream areas. One genus, *Blepharocera*, represented by only four specimens, was found only in downstream riffles in May. Single specimens in the genera, *Limonia* and *Tipula*, were found only at upstream sites.

Of the trichopterans collected, only the family Hydropsychidae (including the genera *Cheumatopsyche* and *Hydropsyche*) and the genus, *Chimarra* (family Philopotamidae) occurred in significant numbers. The great majority of *Chimarra* occurred at one upstream-riffle-station (117 of the 170 total) on one date, September 28. Only one specimen was found on this date at a downstream-riffle-station.

The most abundant coleopteran genus was *Psephenus* which was found in 14 collections downstream and 18 collections upstream with the greatest numbers in

upstream riffles. The elmid *Optioservus* was second most abundant and was equally distributed between downstream and upstream sampling stations. Five other elmids and one dryopid comprised the rest of the beetle fauna.

Plecoptera, with the exception of *Leuctra*, represented a very small portion of the aquatic insect fauna. *Leuctra* was most abundant at the upstream sampling sites. The gastropod *Ferrisia* was the only mollusk collected with any frequency. The other four genera, *Mudalia*, *Lymnaea*, *Physa* and *Fontigens*, were rare.

Organisms which appeared to be the most tolerant to the heated water downstream zone were tubificid worms (*Oligochaeta*) where the greatest increases in temperature above-ambient were recorded. This was

the most apparent in the August collections when stream discharge was at its lowest, 1.12×10^{-1} cms. Chironomids also appeared to be tolerant of higher temperatures.

Diversity—Since it is generally true that relatively undisturbed environments support communities with many species with no one species in extraordinary abundances, it is worthwhile to compare the upstream and downstream benthic communities with a diversity index. The Shannon-Weaver index was chosen as recommended in the EPA Biological Field and Laboratory Methods (1973). Generally, \bar{d} ranges between 3 and 4 with clean, favorable conditions, while \bar{d} is usually less than one in polluted or stressed conditions (Wilhm, 1970).

Figure 4 presents the \bar{d} estimates for the upstream and downstream benthos stations. Although the two riffle and pool areas of the stream are not morphometrically identical, it is felt that comparisons are valid and that major differences due to the heated discharge would be evident. In fact, the upstream riffle consists of a more diverse habitat of water velocities and sub-

strate types, while the downstream riffle consists mainly of a narrower "chute" dominated by boulders and cobbles. Also, the upstream riffle receives more solar radiation since the adjacent bank is where the water pump building is located; and stream border vegetation is, therefore, limited.

There are curious differences in upstream and downstream \bar{d} estimates in July and August when stream discharges were very low (1.6×10^{-1} and 1.12×10^{-1} cms, respectively). At these times, the two downstream stations within the maximally-heated north bank section recorded the two highest total organism counts ($31,172/\text{m}^2$ and $17,254/\text{m}^2$). However, both samples were dominated by oligochaete worms (associated with algae mats) with corresponding low diversity estimates.

A "t" test was used to evaluate mean numbers of taxa and mean (\bar{d}) estimates. The results showed no significant differences ($p = 0.05$) between upstream and downstream stations for the study period when samples were pooled.

The October 1976 stream discharge was high

DIVERSITY (\bar{d}) ESTIMATES FOR UPSTREAM & DOWNSTREAM BENTHOS STATIONS Mill Creek, Botetourt County, Virginia. May-October, 1976

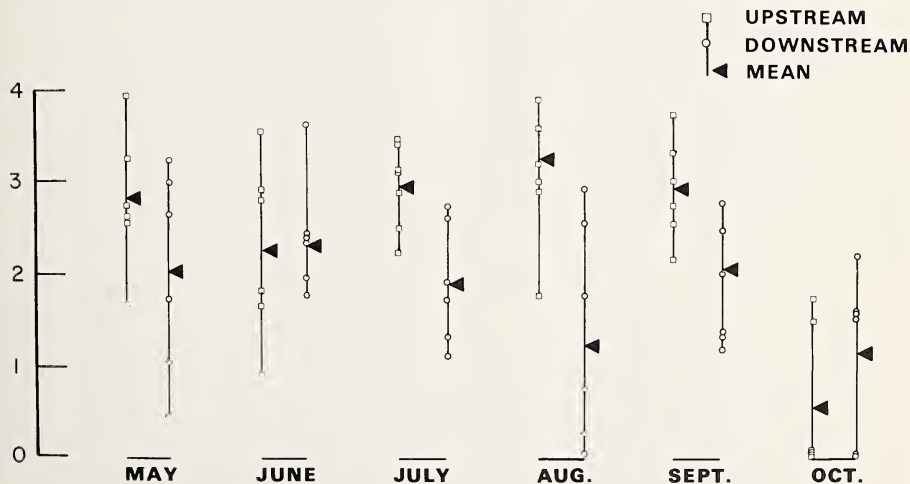


FIG. 4—Diversity (\bar{d}) estimates for upstream and downstream benthos stations, Mill Creek, Botetourt County, Virginia, May-October 1976.

enough to remove the metal stakes which had been established at 30 m intervals in the stream channel. High stream discharges, while causing considerable consternation to the aquatic biologist attempting to study the stream, are natural phenomena in a stream's hydrologic cycle. Hynes (1970) discusses the reductions in abundance and diversity of benthic invertebrates resulting from high water. He cites many references from investigations throughout the world which have revealed the marked reductions in benthic densities following high water discharges. The phenomenon of "drift" usually results in rapid recolonization of the stream substrate when conditions have stabilized.

Mann (1965) in a study of heated effluents and their effects on the invertebrate fauna of the river Thames considered the critical temperature for most benthic invertebrates to lie between 32°C and 35°C. The sampling in August recorded what was probably one of Mill Creek's lowest discharge rates (1.12×10^4 cms), and therefore, resulted in what is most likely the most stressful conditions in terms of departure from optimum biological conditions. Botetourt County experienced severe drought conditions in August 1976 and residents of the area noted that the Creek was flowing "as low as it had ever been." The September sampling indicated recovery of more favorable conditions for stream communities. Unfortunately, the flood conditions of October effectively obliterated the benthic communities in the study area, but it is probable that the upstream and downstream riffles would return to comparable conditions during the winter and spring months.

Although it is only conjecture, it is quite possible that the "warming effect" of the discharge upon the downstream pool and riffle could cause increased biological activity and possible early emergence of some insects. The net effect of this condition, of course, would depend on whether the increased production and early emergence resulted in more available forage for resident fish populations. It is probable, however, that this would be limited to a very small area of the stream since winter and spring downstream warming effects are rapidly attenuated when the thermal discharge is normally well below 2.8×10^2 cms.

It may be concluded that although there were differences between the upstream and downstream benthic populations, these differences were not major when compared over time. Certain organisms, (chironomids and oligochaete worms) appear to be particularly tolerant of increased stream temperatures, and found in abundance when there is a corresponding increase in algal production in the vicinity of the discharge.

Acknowledgements

Appreciation is expressed to Fred Decker, Irwin Unger and Gregory Odegard for field assistance and to the Columbia Gas Transmission Corporation for their support in this study.

Literature Cited

- Biological field and laboratory methods. EPA 670/4-73-0011. 1973. Edited by C. I. Weber. Natl. Environ. Research Center. USEPA, Cincinnati, Ohio 45268.
- Coutant, C. C. and S. S. Talmadge. 1977. Thermal effects. *Jour. Water Poll. Cont. Fed.* June, 1977.
- Hynes, H. B. N. 1970. The ecology of running waters. Univ. Toronto Press. Bunday, Suffolk. 555 p.
- Kennedy, V. S., and J. A. Mihursky. 1968. Bibliography on the effects of temperature in the aquatic environment. Pages 471-568 in *Thermal pollution—1968 (Part I). Hearings Subcommittee, Air and Water Pollut., Commit. Publ. Wks., U.S. Senate, 90th Congress, U. S. Govt. Prntg. Office, Washington, D.C. vi + 598 pp.*
- Mann, K. H. 1965. Heated effluents and their effects on the invertebrate fauna of rivers. *Proc. Soc. Water Treatment Exam.* 14: 45-53.
- Merriman, D. and L. M. Thorpe. 1976. The Connecticut River ecological study. The impact of a nuclear power plant. Monograph No. 1, Amer. Fish. Soc.
- Raney, E. C., B. W. Menzel, and E. C. Weller. 1973. Heated effluents and effects on aquatic life with emphasis on fishes—a bibliography. *Ichthyol. Assoc. Bull.* no. 9, and AEC Tech. Info. Services, Rept. no. TID-3918, Oak Ridge, Tennessee. 651 pp.
- Robins, R. C. and R. W. Crawford. 1954. A short accurate method of estimating the volume of stream flow. *Jour. of Wildl. Mgmt.* 18: 366-369.
- Wilhm, J. L. 1970. Range of diversity index in benthic macroinvertebrate populations. *Jour. Water Poll. Cont. Fed.*, 42(5): R221-R224.

Forests of Small Stream Bottoms in the Peninsula of Virginia

Susan Glascock and Stewart Ware

Department of Biology
College of William and Mary
Williamsburg, Virginia 23185

Abstract—A forest community small in extent but frequently encountered in the Virginia Coastal Plain is the bottomland forest of small streams. These long, narrow, flat areas along twisting and often braided streams are bounded by usually sharply rising slopes with a strikingly different forest type. Seventeen fairly mature small stream bottom forests were sampled by the Bitterlich method, and arranged in a Bray-Curtis type ordination. Most stands were dominated by some combination of red maple, ash (mostly *Fraxinus pennsylvanica*), and American elm. These stands, along with two dominated by baldcypress, fell in the upper right portion of the ordination. Stands with a high importance of American hornbeam and tuliptree fell in the lower middle portion of the ordination, and willow oak and sweetgum occupied the left side of the ordination. Swamp trees like water tupelo, water hickory, swamp cottonwood, silver maple, and box elder were absent from the sampled stands, though the first three do occur in some Peninsula of Virginia river swamps. Three other species often regarded as bottomland trees elsewhere in the Atlantic Coastal Plain (loblolly pine, beech, and sweetbay) were of low importance and are more abundant in uplands in the Peninsula.

Introduction

A forest type small in extent but frequently encountered on the Coastal Plain of Virginia is the bottomland forest of small streams. These long, narrow streamside forest communities have a high water table and/or experience temporary flooding at irregular intervals. The composition of the forest changes abruptly as one moves from the very level floodplain bordering the twisting and often braided streams onto the adjoining (and usually steeply rising) slopes, so the total area covered by the bottom forests is not great. Ecological studies have been made of Coastal plain hardwood swamps in Alabama (Gemborys and Hodgkins 1971), Florida (Monk 1966), and New Jersey (Bernard 1963), but no such studies have been published on the Atlantic Coastal Plain between New Jersey and Florida. Though there have been geographically nearer studies that included small stream bottom forests, these were in the Piedmont (Oosting 1942 in North Carolina; Gemborys 1974 in Virginia) or at the Piedmont-Coastal Plain boundary (Hotchkiss and Stewart 1947 in Maryland). The purpose of the present study was to determine the vegetational composition of small stream bottoms in the central Coastal Plain of Virginia, and to relate their composition to previous studies of similar communities elsewhere.

The Study Area

The area of study is located between the James and York Rivers in the Coastal Plain in James City, Charles City, and New Kent Counties, Virginia (Fig. 1). In this area, stream bottoms are less likely to show signs of recent disturbance than upland sites, for the bottoms are too wet for either cultivation or profitable pine production, and are frequently left unmolested. Despite the lack of recent disturbance, there are probably no virgin bottom forests. The timber of all sampled stands were clearly second growth. Even the largest trees encountered (*Taxodium distichum* in stand 11) were much smaller than some rotting stumps, presumably relics of a virgin condition, found in stands 4, 10, and 16.

A large number of small stream bottoms encountered in the study area, while showing no signs of recent timbering, were covered with standing dead trees. These areas, often partly flooded, were located where streams are crossed by fairly recently built

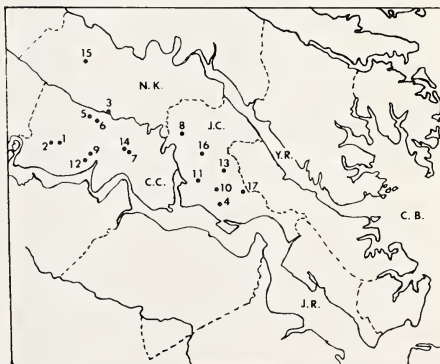


FIG. 1.—Distribution of seventeen sampled bottomland stands in the Coastal Plain of Virginia. C.B. = Chesapeake Bay; J.R. = James River; Y.R. = York River; N.K., C.C., and J.C. are abbreviations for New Kent, Charles City, and James City counties.

highways. It seems probable that the recent death (within the last ten years) of the trees resulted from the disturbing action of roadbuilding, which may have drastically changed the moisture conditions. If the conduits under the road are insufficient to handle all the water flow during flood stages, the depth, frequency, and especially the duration of flooding may have increased greatly since the construction of the highways, causing massive tree die-off.

Methods

U.S. Geological Survey topographic maps were used to locate forested sites lying along non-tidal streams that were accessible from public roads. Sites were then visited to determine whether they were suitable for study. Stands were excluded if they appeared

recently disturbed, contained many dead trees, were not homogeneous, appeared to be permanently or semi-permanently flooded, or were too small to permit an adequate sample. Seventeen stands were sampled in the summer of 1975.

Dominance was measured (m^2/ha , cross-sectional area breast high) by the Bitterlich method, using a Spiegel Relaskop (sighting prism). The density of each species (tree/ha) was based on counts of stems ≥ 10.16 cm (4 in) dbh found in circular plots with a 10 m diameter. Relative dominance and relative density were calculated and averaged to yield relative importance value (I.V.). Using the I.V. data an ordination of stands was established following the Bray-Curtis techniques as employed by Gemborys (1974). Because the third (Z) axis was essentially the same as the X axis, the

Table 1. Species Ranking Among the Top Three in at Least One of Seventeen Sampled Stands

Species	# Times Achieving Rank in Stand of			Stands With I.V. >10	# Stands Where Present	Maximum Importance Value
	1	2	3			
<u>Acer rubrum</u>	5	4	1	10	17	43.4
<u>Fraxinus pennsylvanica</u>	3	3	2	8	15	49.4
<u>Liquidambar styraciflua</u>	2	3	3	8	15	38.6
<u>Carpinus caroliniana</u>	2	2	2	7	15	26.9
<u>Ulmus americana</u>	-	-	4	5	14	17.0
<u>Quercus phellos</u>	2	-	1	2	9	64.2
<u>Quercus michauxii</u>	1	-	1	3	9	20.9
<u>Taxodium distichum</u>	1	1	-	2	3	30.7
<u>Quercus nigra</u>	1	-	-	1	3	23.4
<u>Liriodendron tulipifera</u>	-	1	1	2	10	17.9
<u>Nyssa sylvatica</u>	-	1	-	2	11	23.2
<u>Fagus grandifolia</u>	-	-	1	2	9	12.1
<u>Ilex opaca</u>	-	1	-	1	6	20.3
<u>Betula nigra</u>	-	1	-	1	5	20.2
<u>Pinus taeda</u>	-	-	1	1	11	17.4
<u>Quercus pagodaefolia</u>	-	-	1	0	6	8.2

ordination was established using only the X and Y axes.

Nomenclature follows Radford, Ahles, and Bell (1968). Ashes were identified as *Fraxinus pennsylvanica*, but the identifications were made in summer using vegetative characters, and while an autumn check revealed that all of the trees examined bore fruit of *F. pennsylvanica*, *F. profunda* fruits were found on the ground in two swamps, so this species may be included in some of our samples.

Results

Of the 34 species of trees found in the sampled stands, 8 species were leading dominants in at least one stand. Seven other species had an I.V. > 10 in one or more stands (Table I). Stands 1 and 17 formed the two reference stands of the X axis, being 97.45 dissimilarity units apart. *Quercus phellos* (I.V. = 45.5) dominated the first reference stand, while *Fraxinus pennsylvanica* (I.V. = 49.4) and *Acer rubrum* (I.V. = 31.8) dominated the second reference stand. On the Y axis, 82.3 units long, stands #9 (*Carpinus caroliniana*, I.V. = 26.9; *Ilex opaca*, 20.3) and #7 (*Liquidambar styraciflua*, 36.8; *Acer rubrum*, 23.4) were the reference stands. When species of high importance were plotted on the ordination, they tended to fall into one of three general areas on the ordination (Fig. 2). It should be emphasized that the spatial locations on the ordination are not necessarily of environmental significance, but show an abstract relationship based on the relative similarity of the stands to one another.

Most stands were found in the upper right hand corner of the ordination. These stands were mainly

dominated by *Acer rubrum*, and high importance values for this species show a distinct pattern of concentration in that area. *Fraxinus pennsylvanica*, *Ulmus americana*, and *Nyssa sylvatica* exhibited the same pattern of concentration in this portion of the ordination, and *Taxodium distichum* attained its only high values in two stands in this area. *Carpinus caroliniana*, on the other hand, had its highest importance values in stands located at the central lower area of the ordination. The less important species *Betula nigra* and *Fagus grandifolia* show the same pattern. *Ilex opaca* reached its only high I.V. there, and *Platanus occidentalis* is more consistently present here than elsewhere. *Liriodendron tulipifera* had its highest importance values in the lower middle area, but the values decreased gradually into the *Acer rubrum*-dominated upper right area.

A third region of concentration appears in the upper left portion of the ordination, where *Liquidambar styraciflua* and *Quercus phellos* have their highest I.V.'s. *Quercus nigra* is a leading dominant in one stand there.

Quercus michauxii had at least one high importance value in all three 'corners' of the ordination, with no area of concentration. *Pinus taeda* was abundant in the upper central portion of the ordination, and therefore was dissociated from all three 'centers' of concentration.

Although stands in general were selected to have similar moisture conditions, there were moisture differences among our stands. Obvious differences were noted qualitatively, but these subjective judgments are of questionable worth because the observations on amount of moisture present are based on only a few visits to each stand. With the weakness of our evidence in mind, we report that the stands located in the *Carpinus* region of the ordination tended to have lower soil moisture. Stands 8 and 5 are recorded as "dry" and Stand 9 was recorded as "very dry". These are three of the four stands located in the primary *Carpinus* region. Stand 1, located in the far upper left corner of the ordination, had evidence of deep flooding by very rapidly moving water in the spring, but was nonetheless very dry during summer visits. Stand 11, located in the *Acer*/*Fraxinus* segment of the ordination, was a very wet cypress swamp, with some standing water all year. The remaining stands, despite the differences in their composition, were not obviously different from one another in soil moisture during our visits.

Discussion

Though our swamps tended to fall into three general types, there is a great deal of overlap in the distribution of species from the various groups. *Carpinus caroliniana* and *Liquidambar styraciflua* especially reach fairly high I.V. (> 10) in stands basically dominated by *Acer* and *Fraxinus*. Oosting (1942) found *Liquidambar* to be less sensitive to environmental differences than *Fraxinus*, *Ulmus*, *Acer* and *Liriodendron*, and noted that it was adapted to a variety of conditions. Perhaps *Carpinus* is also widely tolerant, for it was recorded in all but two of our stands (14 and

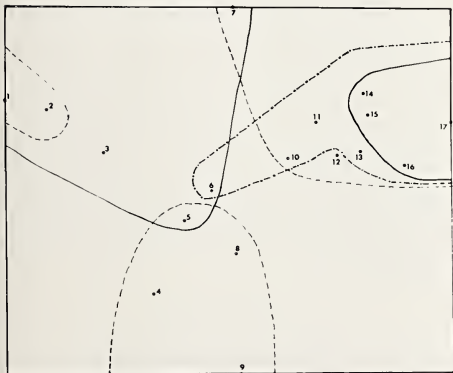


FIG. 2.—An ordination showing areas of greatest importance of six major species. The solid line in the upper right encloses those stands where *Ulmus americana* I.V. ≥ 11 ; the dot-dashed line encloses those with *Fraxinus americana* I.V. ≥ 14 ; the upper left solid line, *Liquidambar styraciflua* ≥ 12 ; the upper left dashed line, *Quercus phellos* I.V. ≥ 40 ; the lower central dashed line, *Carpinus caroliniana* I.V. ≥ 16 .

17). In most stands the number of *Carpinus* recorded was only a small percentage of the number present, because most were too small ($<4"$ dbh) to be included in our sample. In the stands where *Carpinus* was more important, it appears there were larger *Carpinus* trees rather than a great number of *Carpinus* individuals. Perhaps in those stands cutting occurred at such a time that *Carpinus* was "released" from growth inhibition due to shade, and has thus grown much faster under the open canopy. One of us (SW) has observed this occurrence in *Ilex opaca* in selectively cut upland forests of the area. The greater abundance of *Platanus occidentalis* and *Betula nigra* (both successional, shade intolerant species) in stands in which *Carpinus* is more important strengthens our interpretation that these stands may have been more open in the past, perhaps as a result of selective timbering. However, if our notion that *Carpinus* has increased in importance because of release through selective timbering is correct, then the relationship between *Carpinus* importance and drier sites discussed above, if valid, must not be a direct one.

It is generally agreed that *Taxodium distichum* is one of our most flood resistant species, and Bernard (1963) and Gemborys and Hodgkins (1971) regarded *Acer rubrum* as extremely moisture tolerant. Considering that *Quercus nigra* and *Quercus phellos* are both regarded as less flood tolerant than *Fraxinus americana* and *Acer rubrum* (Fowells 1965), one could interpret the ordination as representing a general moisture gradient from the left and lower *Quercus phellos*/*Carpinus caroliniana* areas to the upper right *Acer*/*Fraxinus*/*Taxodium* areas. Without quantitative measurement of soil moisture and depth, frequency, and duration of flooding, however, we are reluctant to make such a generalization. A desirable follow up of our study would be a season-long study of these moisture parameters in a group of bottoms with varying vegetational composition.

Penfound (1952) in describing southern swamps listed six shallow swamp communities. The community which appears most similar to the bottoms of this study is the *Acer*/*Liquidambar*/*Quercus* swamp. In that community, *Fraxinus pennsylvanica*, *Acer rubrum* and *Liquidambar styraciflua* are important, just as in our stands, but also important are *Quercus palustris*, *Platanus occidentalis* (both of low importance in our study), *Salix nigra* (we recorded one tree), and *Populus deltoides* (which we did not encounter at all). Further, Penfound (1952) described this community as transitional (successional). Similarly, Bernard (1963) described New Jersey bottoms having *Acer rubrum* as the most important dominant as successional. However, Monk (1966) concluded that the "mixed swamps" he sampled, dominated by *Acer rubrum*, *Nyssa sylvatica*, *Liquidambar styraciflua*, *Taxodium distichum* (plus two species we did not find, *Fraxinus caroliniana* and *Sabal palmetto*) are climax communities. While we did not examine quantitatively the smaller age classes in our study, we saw no evidence to suggest that a dramatic change of composition might occur in the future.

Our swamps seem to be more like those Florida swamps in this respect.

Perhaps as interesting as what we found in our bottom forests was what we did not find. Gemborys and Hodgkins (1971) and Monk (1966) found *Quercus nigra* to be important in Coastal Plain small stream bottoms, while it appeared in only three of our stands, and was structurally important in only one. *Magnolia virginiana* was found to be important by Gemborys and Hodgkins (1971), Monk (1966), and Bernard (1963), and it occurs in our area both in uplands and at the heads of small streams, but it was not present in any of our bottom forests. Seven other species which are sometimes structurally important in swamps of the North Carolina Coastal Plain (A. E. Radford, personal communication 1976) were also absent from our stands. Three of these (*Acer negundo*, *A. saccharinum*, *Populus deltoides*) are encountered in our area as planted shade trees on uplands, but apparently are not part of the native vegetation. Gemborys (1974) did not find the last two species to be important in Piedmont bottoms either, since his study site was also outside their natural range (Fowells, 1965), but he did find *Acer negundo* a leading dominant in one of his stands. Two other of the seven species, *Quercus laurifolia* and *Carya aquatica*, are very rare in our area. The last two species, *Populus heterophylla* and *Nyssa aquatica*, occur not infrequently in deep water swamps in our area, but were not in any of our sampled small stream bottoms.

Though there were numerous floristic and vegetational differences, *Acer rubrum*, *Fraxinus* spp., *Nyssa sylvatica*, *Liquidambar styraciflua*, *Magnolia virginiana*, and *Ulmus* spp. are the most consistently important species in the studies by Gemborys and Hodgkins (1971), Monk (1966), Gemborys (1974), Bernard (1963), and the present study. Of all trees ranking among the six most important non-conifer species in at least one of the study areas listed above, only *Sabal palmetto* (of Florida) and *Magnolia virginiana* were absent from the Virginia Coastal Plain swamps, and these plus *Platanus occidentalis* (of the Virginia Piedmont) were the only ones which did not assume major structural importance in at least one Virginia Coastal Plain stand. Thus, despite the broad geographical area involved, there is remarkable structural similarity among the Alabama, Florida, Virginia Piedmont, Virginia Coastal Plain, and New Jersey small stream swamps.

Literature Cited

- Bernard, J. M. (1963): Lowland Forests of the Cape May Formation in Southern New Jersey. *Bull. N.J. Acad. Sci.* 8:1-12.
- Fowells, J. A. (1965): Silvics of Forest Trees of the United States, 762 p. Agricultural Handbook No. 271; USDA, Washington, D.C.
- Gemborys, S. (1974): The Structure of Hardwood Forest Ecosystems of Prince Edward County, Virginia. *Ecol.* 55: 614-621.
- Gemborys, S. and Hodgkins, E. J. (1971): Forests of Small Stream Bottoms in the Coastal Plain of Southwestern Alabama. *Ecol.* 52:70-84.

- Hotchkiss, N. and Stewart, R. E. (1947): Vegetation of Patuxent Refuge, Maryland. *Am. Midl. Nat.* 38:1-75.
- Monk, D. D. (1966): An Ecological Study of hardwood Swamps in North Central Florida. *Ecol.* 47:649-654.
- Oosting, H. J. (1942): An Ecological Analysis of the Plant Communities of Piedmont, North Carolina. *Amer. Midl. Nat.* 28:1-126.
- Penfound, W. T. (1952): Southern Swamps and Marshes. *Bot. Rev.* 18:413-445.
- Radford, A. E., Ahles, H. E. and Bell, C. R. (1968): *Manual of the Vascular Flora of the Carolinas*. UNC Press, Chapel Hill.

More Oribatid Mites in the Vicinity of Mountain Lake Biological Station, Virginia (Acariformes: Oribatida)

Howard G. Sengbusch

Professor of Biology
State University College at Buffalo
Buffalo, New York 14222

Abstract—Sixteen additional oribatid mites, their collection sites and substrate, are reported from the vicinity of Mountain Lake biological Station, Virginia.

Introduction

A number of years ago I published a checklist of ninety-five species of oribatid mites found in the region of Mountain Lake, Virginia (Sengbusch 1957). The annotated list provided information on each collecting site and on the type of substrate in which the mites were found. At that time it was noted that the report should be considered preliminary.

Recently in re-examining approximately four hundred mounted microslides prepared during the above investigation, sixteen additional species of oribatid mites were discovered. Since the original paper contains the materials and methods, as well as a map of the collecting sites, there is no need to reproduce them here. In the intervening twenty years, however, there have been significant changes in the taxonomy of this group, so that the following list was classified according to Balogh (1972) and Krantz (1978).

Annotated List

(Arachnida: subel. Acari: order Acariformes: suborder Oribatida)

Supercohort Macropylina (Oribatei Inferiores)

Cohort Arthronotina

Superfamily Parhypochthonoidea

Family Parhypochthoniidae

1. *Parhypochthonius gracilior* (Jacot) 1938.
Leaf litter, Tawney's Cave entrance.

Superfamily Northroidea

Family Malacostrididae

1. *Trimalaconothrus novus* (Sellnick) 1921.
Wet moss, Old West Virginia Road.
Supercohort Brachypylina (Oribatei Superiores)

Cohort Apterogasterina (Gymnionota)

Superfamily Hermannielloidea

Family Hermanniellidae

1. *Hermanniella picea* (C. L. Koch) 1840.
Leaf litter, Tawney's Cave entrance.

Superfamily Belboidea

Family Belbodamaeidae

1. *Porobelba parki* Jacot 1937. Leaf litter,
Tawney's Cave entrance and exit.

Family Damaeidae

1. *Epidamaeus bakeri* (Hammer) 1952.
Moss (*Hylocomium brevirostre*), Little
Stony Creek.

Superfamily Eremuloidea

Family Eremobelbidae

1. *Eremobelba gracilior* Berlese, 1908. Moss,
Little Stony Creek; lichens on white
oak; litter, Tawney's Cave entrance.

Superfamily Eremaeidea

Family Eremaeidae

1. *Eremaeus brevitarus* (Ewing) 1917.
Litter, Tawney's Cave exit.
2. *E. hepaticus* C. L. Koch, 1836. Lichens
on black oak; moss, Bald Knob.
3. *E. translamellatus* Hammer, 1952. Wet
moss, Cascades; lichens on red and black
oaks; litter, Castle Rock.

Superfamily Carabodoidea

Family Carabodidae C. L. Koch, 1837

1. *Carabodes labyrinthicus* (Michael) 1870.
Moss, Bald Knob.

Superfamily Otocephoidea

Family Suctobelbidae

1. *Suctobelba acutidens* Forsslund, 1941.
Moss, Bald Knob.
2. *Suctobelba palustris* Forsslund, 1951.
Litter, Castle Rock.
3. *Suctobelba (Suctobelbella) frothinghami*
(Jacot) 1937. Moss, Bald Knob.
4. *Suctobelba (Suctobelbella) hurshi*
(Jackot) 1937. Litter, Tawney's Cave exit.
5. *Suctobelba (Suctobelbella) longispis*
(Jacot) 1937. Moss, Bald Knob.

Cohort Pterogasterina (Poronota)

Superfamily Oribatulioidea

Family Oribatulidae

1. *Phauloppia lucorum* (C. L. Koch) 1741.
moss, Cascades; lichens on white and
black oaks.

Literature Cited

- Balogh, J. 1972. The Oribatid Genera of the World. Akademiai Kiado, Budapest.
- Krantz, G. W. 1978. A Manual of Acarology, 2nd Ed. Oregon State University Book Stores, Inc. Corvallis.
- Sengbusch, H. G. 1957. Checklist of Oribatoid Mites in the Vicinity of Mountain Lake Biological Station—Virginia (Acarina, Oribatei). The Va. J. Sci. 8(2): 128-134.

NOTES

APPLICATION FOR MEMBERSHIP
VIRGINIA ACADEMY OF SCIENCE

Box 8454, Richmond, Virginia 23226

Name (Please Print) _____

Address (P.O. Box or Street) _____

City State Zip

Institution or Business _____

Position - Title _____

Field of Interest, Section No. _____

Date _____ Class of Membership Desired  _____ Contributing _____ Sustaining
 _____ Regular _____ Student
 _____ Business

Contacted by: _____

Make check payable to VIRGINIA ACADEMY OF SCIENCE and send to above address.

MEMBERSHIP

The Academy membership is organized into sections representing the various scientific disciplines.

Addressograph plates of all members are coded by number. The First Number indicates the member's section and enables Section Officers to more easily contact members.

- | | |
|-------------------------------------|----------------------------|
| 1. Agricultural Sciences | 9. Medicine |
| 2. Astronomy, Mathematics & Physics | 10. Psychology |
| 3. Microbiology | 11. Education |
| 4. Biology | 12. Statistics |
| 5. Chemistry | 13. Space Sciences |
| 6. Materials Science | 14. Botany |
| 7. Engineering | 15. Environmental Sciences |
| 8. Geology | |

Annual Membership Dues

Approved March 18, 1973

Business Includes subscription to *Virginia Journal of Science*
 Sustaining
 Contributing
 Regular
 Students
 *\$25 or more.

The world of biology at your fingertips!

Biological Materials



0 / 1979-80

Carolina Biological Supply Company

Carolina's New 1979-80 Catalog of Biological Materials

gives you easy access to thousands of
interesting and innovative top-quality
teaching materials.

Request your free copy today!

Carolina Biological Supply Co.

2700 York Rd.
Burlington, North Carolina 27215

Please send me a free 1979-80
Carolina Catalog 50.

Name

Institution

Address

City

State Zip

Carolina Biological Supply Company

2700 York Road
Burlington, North Carolina 27215

Box 7
Gladstone, Oregon 97027

505, 73

V81

VOL. 30, NO. 2
SUMMER 1979

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA

SCIENCE

DUE TO PROBLEMS BEYOND OUR CONTROL
PUBLICATION IS RUNNING VERY LATE.

THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware
Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer
Box 637
Lancaster, Virginia 22503

SECTION EDITORS

Agricultural Sciences

R. J. Stipes
417A Price Hall
VPI & SU
Blacksburg, Va. 24061

Astron., Math. & Physics

Samuel P. Bowen
Dept. of Physics
VPI & SU
Blacksburg, Va. 24061

Biology

Patrick F. Scanlon
Dept. of Fisheries & Wildlife
VPI & SU
Blacksburg, Va. 24061

Botany

David A. Breil
Dept. of Natural Sciences
Longwood College
Farmville, Va. 23901

Chemistry

Roddy G. Bass
Dept. of Chemistry
Va. Commonwealth Univ.
Richmond, Va. 23284

Education

C. Dillard Haley
Dept. of Education
900 Fairfax St.
Radford, Va. 24141

Engineering

Walter R. Hibbard
301 Holden Hall
VPI & SU
Blacksburg, Va. 24061

Environmental Sciences

Michael Garstang
Dept. of Env. Science
Univ. of Virginia
Charlottesville, Va. 22904

Geology

Roddy V. Amenta
Dept. of Geology
James Madison Univ.
Harrisonburg, Va. 22801

Materials Science

John C. Duke, Jr.
Dept. of Eng. Sci. & Mechanics
VPI & SU
Blacksburg, Va. 24061

Medical Sciences

Charles O'Neill
Dept. of Biophysics
MCV
Richmond, Va. 23298

Microbiology

Paul V. Phibbs, Jr.
Dept. of Microbiology
MCV-VCU
Richmond, Va. 23298

Psychology

Frank S. Murray
Psychology Dept.
Randolph-Macon Women's College
Lynchburg, Va. 24503

Space Science & Technology

Sam S. Fisher
Dept. of Mechanical and Aero-Space
Engineering
Thorton Hall, Univ. of Va.
Charlottesville, Va. 22901

Statistics

J. Van Bowen, Jr.
Dept. of Mathematics
Univ. of Richmond
Richmond, Va. 23172

©Copyright, 1979 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P.O. 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia and additional entry at Harrisonburg, Virginia 22801. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1979: \$15.00 per year, U.S.A.; \$20.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$4.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send *address changes* to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper (8½ × 11 inches). Margins should be not less than 1¼ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and

affiliation, and proposed running title, all appearing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year-format: Fujishima and Honda (1972), or Spry (1969), or Guilday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first and last page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. Metamorphic Textures. Pergamon Press, New York. 350 pp.

Guilday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians, Part III. Vertebrates* (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 30

No. 2

Summer 1979

TABLE OF CONTENTS

REPORT OF THE PRESIDENT, 1979

Dale Ulrich

COMMITTEE REPORTS

ABSTRACTS OF PAPERS, *Fifty-Seventh Annual Meeting of the Virginia Academy of Science,
May 8-11, 1979, University of Richmond, Richmond, Va.*

Agricultural Sciences	30
Astronomy, Mathematics, and Physics	39
Biology	45
Botany	54
Chemistry	60
Education	69
Engineering	72
Environmental Science	75
Geology	79
Materials Science	82
Medical Science	88
Microbiology	98
Psychology	103
Space Science and Technology	107
Statistics	110

President's Report

It is an honor to present this report to the membership of the Virginia Academy of Science. Because so many members gave freely of their time and abilities to strengthen the Academy in its service to the scientific community of Virginia, serving as the 56th President of the Academy in 1978-79 provided many gratifying experiences.

During the course of a typical year, several invitations are received for the Academy to be represented at a variety of functions; the past year was no exception. Following is a list of such occasions in 1978-79:

On February 9-10, Drs. Ertle Thompson, Dennis W. Barnes, and Herbert McKennis, Jr. represented the Academy at the Conference on Environmental Law - Toxic Substances which was sponsored by the Marshall-Wythe School of Law, College of William and Mary.

On February 17, President Ulrich represented the Academy at the dedication of a lecture hall in memory of the late Wilbur T. Harnsberger, Jr., a fellow of the Academy and Chairman of the Local Arrangements Committee in 1975. Harnsberger Lecture Hall is located in the new physical science building at James Madison University.

On March 29-31, Dr. William J. Watts represented the Academy at the Governor's Conference on Libraries.

On April 7, Past-President Ralph A. Lowry represented the Academy at the inauguration of Dr. George W. Johnson as President of George Mason University.

Each year the Academy's Research Committee considers proposals for small grants to support scientific research by Academy members. These grants are made possible by an endowment which is specified for that purpose, and in recent years, members of the Academy have been invited annually to contribute to that endowment. Dr. Edgar S. Spencer, Chairman of the Research Committee, has reported that the following grants were awarded in 1978-79:

\$300 to Dr. W. J. Matthews, Biology Department, Roanoke College

\$150 to Dr. S. B. Ackerman, Biology Department, Old Dominion University.

\$200 to Dr. Scott Geller, Psychology Department, Virginia Polytechnic Institute and State University.

\$491.81 to Dr. Carl Erkenbecker, Jr., Biology Department, Old Dominion University.

\$353.50 to Dr. Dennis Darby, Geology Department, Old Dominion University.

Proposals for research grants in the range of \$500 or less may be submitted to the 1979-80 Chairman of the Research Committee: Dr. Herbert McKennis, Jr., Department of Pharmacology, MCV-VCU, Box 726, Richmond, VA 23298.

The Annual Meeting is the highlight of each Academy year. The excellent and beautiful facilities of the University of Richmond with the thorough planning and efficient work of Mrs. Vera B. Remsburg, President-elect, and the Local Arrangements Committee (chaired by Dr. Frank Leftwich) combined to make the 1979 Annual Meeting a truly outstanding one. Included on the program were 446 scientific papers and a full Virginia Junior Academy of Science program. Encouraging brilliant young people in their pursuits of scientific work is a vital contribution to future generations which the Academy is continually making, and the Annual Meeting plays an essential role in that effort.

Each year, the J. Shelton Horsley Award is made for the outstanding paper presented at the Annual Meeting. This year a committee of members of the Virginia Academy of Science selected Dr. W. L. Dewey of the Department of Pharmacology, Medical College of Virginia, as the 1979 recipient of this coveted award for his paper entitled "Evidence for the Release of Enkephalins and Other endogenous Opiates by Morphine."

At the conclusion of the 1978 Annual Meeting, Council recommended that the annual Sidney S. Negus Memorial Lecture take the form of a symposium in 1979. With the assistance of Dr. Arthur W. Burke and Miss Virginia C. Ellett, Co-Chairman of the Committee on Scientific Education, and Dr. Ertle Thompson, Chairman of the Committee to Plan a Science Advisory System, the President arranged for the Sidney S. Negus Memorial Symposium on the topic "The Commonwealth-Science Education and Technology." Panel participants were the Honorable Maurice B. Rowe, Secretary of Commerce and Resources; Dr. W. E. Campbell, Superintendent of Public Instruction; Dr. Frank L. Hereford, Jr., President, University of Virginia; and Dr. Helmut Wakeham, Vice-President for Science and Technology, Philip Morris, Inc. Their papers will be printed in a later issue of the Virginia Journal of Science.

VAS Council meets each fall and late winter in addition to two meetings during the Annual Meeting. It is through its committee structure that the Academy deals with problems that arise, responds to opportunities, and plans its future. The annual reports by the committee chairmen which are printed below highlight an increase in membership in 1978-79, budgetary concerns, and numerous programs. One of the major problems facing the academy in this inflationary period is the task of publishing the Virginia Journal of Science within a budget which the Academy can afford. The Academy is fortunate that the new Editor, Dr. Stewart A. Ware, and the new Business Manager, Mr. Franklin D. Kizer, are committed to doing everything possible to achieve that goal.

In conclusion, it is a pleasure to report that the Virginia Academy of Science is a healthy, vigorous organization which is responding to its concerns in a thoughtful, organized manner with the clear goal of serving better the interests of the scientific community and the common good in Virginia.

Respectfully submitted,

Dale V. Ulrich

President, 1978-79

Virginia Academy of Science

Fifty-Seventh Annual Meeting, University of Richmond

May 8-11, 1979

Visiting Scientists Program

In April, 1978, permission was obtained from Dr. W. E. Campbell, Superintendent of Public Instruction, State Department of Education, to conduct the visiting Scientists Program in the public schools of the Commonwealth during the 1978-79 academic year. Notice of this permission was conveyed to each Division Superintendent from the State Superintendent's Office in Supts. Memo. No. 97, May 5, 1978.

Also, in May commitments were obtained from the Presidents of thirty-two colleges and universities in Virginia to pay the travel expenses of their faculty members who would be invited to give lectures under the Visiting Scientists Program. Multiple copies of the 1978-79 Visiting Scientists Program were distributed to each high school in Virginia in September.

In January, 1979, each speaker listed in the 1978-79 Visiting Scientists Program was sent a copy of the Program and a letter thanking them for their participation. Also, the 377 speakers who were not members of the academy were each sent an invitation to join the Academy, an Academy brochure, and a membership application.

The 1978-79 Visiting Scientists Program has been very successful with 617 participating scientists and educators offering 972 topics to Virginia high schools and science clubs. Reports of visits received from the schools this year indicate that 3716 students have enjoyed lectures and demonstrations by visiting scientists. This represents an 18.6% increase over last year. Several high schools have used the Visiting Scientists Program in their programs for gifted students and many find letters of appreciation have been received.

Working with the Visiting Scientists Program has been a rewarding experience. Recently, other responsibilities made it necessary for me to discontinue serving the Academy as the Director of the program. Dr. Harold M. Bell of the Chemistry Department at Virginia Polytechnic Institute and State University is the new Director of the Visiting Scientists Program. I am certain that each member of the Academy joins me in strongly supporting Dr. Bell in his newest service to the Academy.

Gerald R. Taylor, Past President

The Awards Committee

The Committee reviewed nominations and recommended the Council election as Fellows of the Virginia Academy of Science: S. Gaylen Bradley, professor and Chairman, Department of Microbiology, Virginia

Commonwealth University and Secretary of the Academy, 1976-1978; Addison D. Campbell, Professor of Physics, University of Richmond; William M. Hinton, Professor Emeritus of Psychology, Washington and Lee University and President of the Academy, 1959-1960; William L. Mengebier, professor and Chairman, Biology Department, Bridgewater College; Maurice B. Rowe, Secretary of Commerce and Resources, Commonwealth of Virginia and President of the Academy, 1970-71; Jackson J. Taylor, Chairman of the Department of Physics, University of Richmond, and President of the Academy, 1962-1963; Ertle Thompson, New School of Education, University of Virginia.

The Committee proposed and recommended to Council, election as an Honorary Life Member in the Virginia Academy of Science, Edward S. Harlow, retired Vice President of the American Tobacco Company and President of the Academy, 1956-1967, in recognition of his long service and devotion to the Academy. Dr. Edward F. Turner, Jr., Professor of Physics and Department Head, Washington and Lee University, until his untimely death September 30, 1978 was selected for posthumous presentation of the Ivey F. Lewis Distinguished Service Award for 1979 for his love of the Academy and for his continued and extraordinary support of it. He was President, 1971-72.

Members were urged to submit nominations for Fellows to the Executive-Secretary of the Academy before the June 1 deadline and to send suggestions for the Ivey F. Lewis Distinguished Service Award and for Honorary Life Members to the Awards Committee.

Lynn D. Abbot, Jr., Chairman

The Finance and Endowment Committee

From the Summary of Receipts and Disbursements for 1973-1978 (Table 1), the following highlights may be noted regarding our most recent fiscal year ended 31 December:

1. Gift income is the highest in the five year period. This is due to increased corporate giving, most of which was solicited by the Jr. Academy.
2. Annual meeting receipts increased because of the larger number of exhibitors recruited for the Blacksburg meeting and because of a slight increase in registration fees.
3. Total receipts were up 27% over the average of the previous four years.
4. Journal expense of \$18,088 is 72% over the aver-

age of the previous four years reflecting increased paper and printing costs as well as a somewhat erratic publication schedule. These costs constitute our greatest area of concern in Academy finances at present.

5. The General Fund balance of \$42,749 remains well within the guidelines set by Council of one year's operating expense. 1978 was the first deficit year since the deficits of 1968, 1970, and 1972.
6. The 1979 deficit is projected to be \$8675 on projected expenditures of \$46,275. Journal costs for 1979 are projected to be 45% of total expenses whereas the average for the last decade has been 37%. This highlights further the somewhat increased priority which our publication has taken in the total Academy program.
7. Membership of 1466 at the end of 1978 is up about 100 members, reversing a trend of decreases since 1969 when year end membership was 1707, the all time high for the Academy.

You, the members, remain the key to a successful Academy. By your support in giving papers, recruiting new members and serving on committees, you make the VAS what it is. Your comments and suggestions are welcomed. Please let us know what you think should be our priorities in expending Academy funds.

D. Rae Carpenter, Jr., Chairman

The Fund Raising Committee

The Committee continued its program of giving the membership the opportunity to contribute the support of research by providing a space on the annual dues statement for such a contribution. Several individual, corporate, and foundation prospects were visited by committee members during the year to solicit contributions to the Academy. No grants have been received as yet.

J. Samuel Gillespie, Jr., Chairman

Membership Committee Report

I should like to take this opportunity to thank all members of the Membership Committee who have worked cooperatively during this academy year. They have supplied ideas and have carried out whatever services they were asked to perform.

Recognition should also be made to Dr. Gerald R. Taylor who in his contact with the Visiting Scientist Program distributed membership application blanks and brochures of the Academy to all prospective speakers. Special thanks also go to Dr. Dale Ulrich who in his contact with scientists of the state made continued efforts to secure memberships. Other members of the Academy who have demonstrated interest were called upon to contact prospective members.

Dr. Harold M. Bell of the Chemistry Dept. of V.P.I. & S.U. is the new Director of the V.A.S. Visiting

Scientist Program and is being asked to continue the practice of including application information concerning the academy in his mailings to the potential speakers in the program.

The following will give a more complete picture of the contacts that were made:

1. Persons whose names were on the 1978 program of papers who were not members of the Academy.
2. Persons who had allowed membership to lapse.
3. Section chairmen were requested to contact non-members within their disciplines.
4. All persons on Visiting Scientists Program were sent application blanks and brochures.
5. Persons whose names appeared in the Visiting Scientist Program who were not members of the Academy were contacted a second time.
6. Brochures and membership applications were distributed to an additional number of people through contact by mail and through distribution at the Virginia Science Teachers Meeting.

The results of these efforts have been favorable. The membership has increased during 1978 by 106 new members (Table II). A good deal of effort went into the years activities but because of the favorable results the same type of effort will be exerted during the next year.

Warwick R. West, Jr., Chairman

Publications Committee

During the year, a questionnaire survey regarding the Virginia Journal of Science was distributed to the membership. As reported in the President's Newsletter of November 15, 1978, the response was quite good (about 37% of the membership), and the members favor continuation of the Journal (35% of the responders).

Dr. Kuldip Chopra resigned as Editor of the Journal in May, with the intention of completing Volume 29 (1978). Owing to a combination of circumstances, publication of the remaining issues has fallen behind schedule by a considerable amount, and efforts are being taken to restore the schedule as soon as feasible.

Dr. Stewart Ware, Chairman of the Biology Department at College of William and Mary, has accepted an appointment as Editor effective with Volume 30 (1979). Dr. Ware expects to make a concerted effort to expedite a consistent publication schedule. To do so, he will need the full cooperation of the membership in the submission of materials for publication, and the Publications Committee urges each of you to participate in the continuing success of the Journal as contributors.

An active Business Manager, Frank Kizer, has assumed office. In collaboration with the Editor, the Publications Committee, Council, and the membership, a renewed effort to solicit advertising and to review publication costs has been initiated and will be a continuing concern of the Committee.

John H. Wise, Chairman

FIFTY-SEVENTH ANNUAL MEETING

Table I. Summary of Receipts and Disbursements - 1973-1978

	1973	1974	1975	1976	1977	1978
RECEIPTS						
Dues	\$16,913	\$19,631	\$18,721	\$18,290	\$16,352	\$16,950
Gifts	2,276	2,120	2,505	2,130	2,977	5,417
Annual Meeting	5,497	4,040	5,323	5,794	5,278	9,164
Virginia Journal	4,312	5,168	2,013	1,966	2,568	4,014
Interest	1,425	1,618	1,780	2,130	2,223	1,802
Inc. from Trust Fund	—	2,039	2,000	2,000	3,000	2,200
Other	635	500	676	606	455	674
From Savings & Others	—	—	—	—	—	1,693
	<u>\$31,058</u>	<u>\$35,116</u>	<u>\$33,018</u>	<u>\$32,916</u>	<u>\$32,853</u>	<u>\$41,914</u>
DISBURSEMENTS						
Salaries & Benefits	1,914	2,613	2,117	2,475	2,821	3,105
General Expense	3,027	3,431	3,254	2,879	2,722	—
Meeting Expense	2,575	1,337	2,510	3,248	2,180	3,156
Sponsored Programs-Jrs.	8,875	8,706	10,360	9,349	10,880	10,802
Va. Journal	12,905	14,401	9,079	10,165	6,049	18,088
Committees*	1,000	3,252	2,386	1,825	2,733	3,391
Transf. to Savings & Others	762	1,376	3,313	2,975	4,468	—
	<u>\$31,058</u>	<u>\$35,116</u>	<u>\$33,018</u>	<u>\$32,916</u>	<u>\$32,853</u>	<u>\$41,914</u>
General Fund Assets						
31 December	\$34,887	\$35,144	\$38,455	\$41,851	\$44,442	\$42,749
Research Fund						
Disbursements		\$ 2,860	\$ 2,000	\$ 1,525	\$ 2,000	\$ 2,429
\$ 2,964	incl. above	incl. above	incl. above	incl. above	incl. above	incl. above

*Primarily Research & Flora

Table II. Membership Statistics 1973-1978

Membership Begin. year	1,604	1,563	1,542	1,506	1,426	1,360
Add	156	237	176	111	93	224
Resign & Died	-71	-86	-62	-68	-57	-26
Dropped-Non Pay.	-126	-172	-150	-123	-102	-92
End of Year	1,563	1,542	1,506	1,426	1,360	1,466
<hr/>						
Regular	1,280	1,276	1,233	1,172	1,113	1,165
Contributing	137	113	110	106	100	100
Sustaining	46	43	46	45	46	53
Student	63	73	78	61	63	113
Life	13	13	13	18	17	16
Business	24	24	26	24	21	19

The Trust Committee

The trust funds of the Academy of Science have been under the administration and guidance of First & Merchants in accordance with Council's directive in 1976 to have the funds administered by a trustee. The agreement was dated November 23, 1976, and the status of the trust as of February 21, 1979, was as follows:

Estimated 1979 cash income from the trust	\$ 3,380,000
Principal cash on hand as temporary investment	662.00
Asset carrying value	50,140.33
Market value	45,658.00

The market to book carrying value is .91 to 1, and the return on the investment (carrying value) annualized is 6.7%. The performance of this account appears to be in line with the performance of the market in general, and hopefully the remainder of 1979 will be a better one for the trust than 1978.

The Trust Committee agreed with the recommendation of Rae Carpenter that as the Virginia Academy of Science accumulates income a portion of it should be used to purchase additional units of the Academy Trust Fund. This was in accordance with the recommendation of the senior trust officer and resulted from the Executive Secretary-Treasurer depositing \$662

into the trust fund in January, 1979, while still having approximately \$1,000 of accumulated income in the trust that could be used to purchase additional trust units. The Trust Committee concurred with the recommendation, and the Chairman of the Finance and Endowment Committee and the Executive Secretary-Treasurer were informed that it would be appropriate to take the \$1,000 of accumulated income to purchase additional units in the trust fund.

The Trust Committee believes that the present arrangement with First & Merchants should be continued, and the Trust Committee will continue to monitor the First & Merchants performance and follow the directives of the Council.

Stanley Ragone, Chairman

Ad Hoc Committee on Business Relations

Attempts have been made to encourage additional companies to become business members of the Academy. Emphasis has been placed on companies which have shown interest in the Academy in some way but had not become business members. On the basis of this approach, Allied Chemical has been added to our list of business members. It is hoped that additional companies can be enlisted in this way.

In a meeting of the Business Relations Committee some time ago the suggestion was made to have a symposium at the annual meeting on a subject which would appeal to the industrial scientists. The Chemistry Section, in cooperation with the Business Relations Committee, has planned such a symposium for this 1979 annual meeting. The subject of the Symposium is "Recent Trends in Chemical Research in Industry". The Symposium is scheduled for 1:10 p.m. Thursday, May 10, in the University of Richmond Science Center Auditorium.

W. Allen Powell, Chairman

Ad Hoc Committee to Plan a Science Advisory System

Activities of the Ad Hoc Committee to plan a Science Advisory System during the past year included the following:

1. Review and recommendations relative to the final report of the study of State Science, Engineering and Technology Capacity in Virginia State Government, in cooperation with the Commonwealth of Virginia Department of Intergovernmental Affairs, with support from the National Science Foundation.

As required by terms of the National Science Foundation grant, one element of the overall SSET work plan was to develop an inventory of science, engineering and technology resources available to advise state government on problems with a scientific content. To accomplish this task, a semistructured survey instrument was mailed to the entire membership of the Virginia Academy of Science on October 26, 1978.

This survey (forms appended) was designed to identify persons by scientific specialty who would be willing to serve in an advisory and/or consultative capacity to state government. In addition, the survey attempted to identify the general terms of availability, as noted below:

- a. number of days at no reimbursement
- b. number of days at expense reimbursement only
- c. number of days for consultant fee plus expense reimbursement.

Survey Results

Two hundred five (205) members of the Virginia Academy of Science responded to the survey, indicating both an interest and a willingness to participate in the science advisory system, as their expertise is needed. This represents an impressive base of expertise upon which to build a science advisory system.

A cross-referenced index of individuals and areas of scientific interest and expertise has been compiled by the Chairman of the Ad Hoc Committee on Science Advisory.

The final report and recommendations were made to the Department of Planning and Budget, with a letter of support (copy appended) from the Chairman of the Ad Hoc Advisory Committee on February 22, 1979. A major recommendation was that the Ad Hoc Committee to Plan a Science Advisory System of the Virginia Academy of Science should continue to serve as the Executive Branch's major link to the scientific community as the recommendations are implemented. The Ad Hoc Committee and the Science and Technology Assessment Officer in the Department of Planning and Budget should jointly explore ways to broaden the participation on the Advisory Committee to include other elements of the scientific community, particularly with respect to the social sciences and from the private research-oriented industries.

To date, no action has been taken by Executive Branch relative to the implementation plan as recommended in the report. Therefore, action on the final format of a Science Advisory standing committee within the Academy has been postponed pending response to the SSET Study report.

2. The Chairman of the Ad Hoc Committee on Science Advisory, along with E. L. (Chick) Wisman, represented the Academy at the Association of State Academies in conjunction with the AAAS meeting in Houston, Texas, January 3-8, 1979.
3. Three members of the Ad Hoc Committee, Dennis W. Barnes, Herbert McKennis, and Ertle Thompson, participated in the Conference on Environmental Law—Toxic Substances, at the College of William and Mary, February 9-10, 1979. This conference was one of the first funded

FIFTY-SEVENTH ANNUAL MEETING

by the Virginia Environmental Endowment created by the voluntary contribution of \$8 million in 1977 by Allied Chemical Corporation following the pollution of the James River with Kepone.

4. A test of the proposed advisory mechanism came before executives in government had time to review the proposed plan. The Chairman of the Executive Branch Task Force to study the feasibility of a Virginia Resource Information System requested consultation and advice in the area of physical and natural resources information systems. Using the personnel resource information file compiled to date, supplied to the chairman of the VARIS task force. Ten people were invited to participate in an advisory role in the work of the task force, eight of whom responded favorably. The first working meeting was held at the University of Virginia on March 29, 1979. The work will continue through the summer with the final report to be presented to the General Assembly by December 1, 1979.

Submitted for the Committee: Paul B. Siegel, Maurice B. Rowe, Bernard R. Woodson, Arthur W. Burke, Jr., Dennis W. Barnes, and Herbert McKennis.

Ertle Thompson, Chairman

Ad Hoc Committee on Science Education

The Academy's ad hoc Committee on Science Education cooperated with the Virginia State Department of Education in planning and sponsoring the annual fall State Science Teachers Conference. The 1978 meeting was held at the Hotel Roanoke, Roanoke,

Virginia, and was attended by about 400 supervisors and science teachers from middle and senior high schools across the State. The Virginia Association of Science Teachers (VAST) also co-sponsored this meeting.

The ad hoc Committee on Science Education arranged, through the University of Virginia, School of Education, to offer a special course in Meteorology-Earth Science, which twenty-three teachers completed for one graduate credit in Earth Science. This special course was taught by Drs. Joanne and Robert Simpson, School of Environmental Sciences, University of Virginia, with the assistance of Dr. R. Wesley Batton, Mrs. Ida Beaton, and Mr. P. K. Black of Richmond, Virginia.

The credit course was well received by the teachers and, Dr. Joseph Exline, Associate Director of Science for the State Department of Education, expressed gratitude that it helped provide accreditation in an area of science that is not very accessible to school teachers.

The 1979 fall conference will bring together science supervisors and teachers from all of the levels of public instruction (K-12) for the first time. Plans are well underway to provide a good meeting with a central theme, "The Past, The Present and The Future of Life". Conferences and workshops will be offered which will focus on timely information that will be useful to the school teachers in daily classroom instruction. The 1979 meeting is scheduled for October 5th and 6th at the Cavalier Hotel, Virginia Beach, Virginia.

Virginia C. Ellett and
Arthur W. Burke, Jr., Co-Chairmen

Abstracts of Papers

Agricultural Sciences

**Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond**

PLASMA PROGESTERONE IN DAIRY HEIFERS NEAR PUBERTY. G.W. Anderson*, R.F. Krall*, F.C. Gwazdauskas, D.L. Aalseth* and J.A. Lineweaver. Dept. of Dairy Sci. Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Five Holstein heifers about 12 months of age at the Dairy Cattle Center were used in a study to determine peripheral plasma progesterone concentrations in the peripubertal period. Estrus was not visually detected prior to the study. Heifers were fitted with indwelling polyvinyl jugular catheters and bled (10 ml) daily for 31 days at approximately 1700 hours. Subsequent estrus activity was monitored by use of Kama[®] heat mount detectors and visual observation. Following blood collection, plasma was harvested after centrifugation and frozen at -20C until progesterone was quantified by radioimmunoassay (RIA) techniques. To validate the progesterone assay .5, 1, 2 and 5 ng of progesterone were added to .5 ml plasma. Following organic solvent extraction and RIA .56, .97, 1.77 and 6.69 ng were recovered, respectively. Plasma progesterone was 8.04 ± .45 (\bar{X} ± SEM) ng/ml for the entire study. Progesterone was .22 ng/ml in one heifer on the day of observed estrus. Heifers were inseminated between 2 and 3 months following the last bleeding. All were diagnosed pregnant with 1.4 services per conception. It appears that the corpus luteum of peripubertal heifers is active.

SOYBEAN MILL RUN IN STARTER DIETS FOR WEANED PIGS HOUSED IN TRIPLE-DECK CAGES. S. R. Arthur*, C. L. Gaines*, K. L. Bryant and E. T. Kornegay. Dept. of Animal Science, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Two trials using 66 crossbred pigs averaging 10 lb (five per cage in trial 1 and six per cage in trial 2) were conducted to compare zero and 10% soybean mill run in starter diets. Pigs were housed in an environmentally controlled triple-deck nursery containing six 3 x 4 ft cages (two stacks of three cages each). Pigs were randomly assigned from outcome groups based on sex and weight to treatments. Both diets were fed on each deck. A 22% crude protein corn-soybean meal diet with 10% dried whole whey was fed until the average pen weight reached 15 lb; then a 20% diet to 25 lb; and an 18% crude protein corn-soybean meal diet without whey to the end of the trial. Pigs were on test seven weeks in trial 1 and six weeks in trial 2. Overall average daily gain, feed intake and feed per gain were not different for pigs fed the starter diets with or without soybean mill run. There were no differences ($P > .10$) between pigs housed on the three levels for average daily gain, feed intake and feed per gain. Pigs initially dunged in the rear of the cage and were clean at all levels; however, toward the end of the trial, pigs on the bottom decks were not as clean which probably resulted from dunging over a larger part of the cage due to crowding. The addition of 10% soybean hulls did not improve the performance of weaned pigs.

ECONOMIC DECISION MAKING IN PEST AND DISEASE MANAGEMENT USING VARIOUS GAMES THEORY MODELS. Kenneth H. Baum* and Ronald W. Tillman, Dept. of Agricultural Economics, and Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and St. Univ., Blacksburg, Va. 24061.

Producers of agricultural commodities must make pest and disease management decisions affecting the profitability of their enterprise in a stochastic and uncertain environment. The time lags between the start and end of the production period, or the recognition and treatment of the many pest and disease problems facing producers also complicates management decision choice of economically optimal control strategies. In this paper, the authors suggest these management decision problems can be viewed as games farmers play against "nature" to maximize their net income. Consequently, five game theory models are examined and compared as theories for making pest management choices in the control of apple scab (*Venturia inaequalis*) in an orchard. These models include (1) Wald's maximin criterion, (2) Laplace's principle of "insufficient reason", (3) Hurwicz's "optimism-pessimism" criterion, (4) Savage's "regret" criterion, and (5) the Heady and Agrawal "benefit" criterion.

INBREEDING VERSUS SELECTION IN BEEF CATTLE AT THE FRONT ROYAL STATION. III. WEANING TRAITS BY GENERATION, 1950-69.

K. P. Bovard and W. T. Butts, Jr.*, Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061 and USDA, Knoxville, Tn. 37916

Five preweaning traits, namely birth weight, fall weight, fall ADG (lb/day), weaning time score and pre-test ADG, were studied. Two additional quasi-independent variables, inbreeding of calf, F_c , and inbreeding of dam, F_d , were treated as dependents for certain analyses. Data came from 3663 calves born 1950 through 1969 at the Beef Cattle Research Station, Front Royal, VA. That study was designed to compare two mating systems, intense inbreeding and mass selection, in Angus, Hereford and Shorthorns. Separate least squares (L.S.) analyses were made for each sex-breed class using a model that fit for age of dam, calf age in days, and calf generation within line and mating system. From the 30 L.S. analyses of the five traits first named above, R-squared values ranged from .13 to .59. In contrast, R-squared values for inbreeding of calf and of dam ranged from .36 to .87. In Angus bull calves, for example, changes in fall weight ranged from -1.15 to -23.10 lb/generation among inbreds; values were 3.03 and 15.84 in type and growth selection lines, resp; changes in F_c ranged from 9.3 to 15.7% per generation among inbreds; values were -.2 and .7% in type and growth selection lines, resp. Results were similar for comparable sex-mating system classes.

INBREEDING VERSUS SELECTION IN BEEF CATTLE AT THE FRONT ROYAL STATION. IV. POSTWEANING TRAITS BY GENERATION, 1950-69. K. P. Bovard and W. T. Butts, Jr.*. Dept. Animal Science, VPI & SU, Blacksburg, VA. 24061 and USDA, Knoxville, TN 37916

Three postweaning traits, namely pre-test ADG (lb/day), test ADG, and yearling type score were studied. Two additional quasi-independent variables, inbreeding of calf, Fc, and inbreeding of dam, Fd, were treated as dependents for certain analyses. Data came from 2611 calves born 1950 through 1969 at the Beef Cattle Research Station, Front Royal, VA. That study was designed to compare two mating systems, intense inbreeding and mass selection, in three breeds. Separate least squares analyses were made for each sex-breed class using a model that fit for age of dam, calf age in days, and calf generation within line and mating systems. Numbers of bull, heifer and steer calves in Angus were 224, 589 and 129, resp., in Herefords were 154, 500 and 85, resp., and, in Shorthorns were 228, 553 and 149, resp. From the 27 L.S. analyses of the first three traits cited above, R-squared values ranged from .06 to .44. In contrast, R-squared values for Fc and Fd ranged from .26 to .87. In Angus bull calves, for example, changes in test ADG ranged from .01 to .14 per generation among inbreds; they were .12 and .19 for type and growth selection lines, resp. Other results were similar for comparable sex-mating system classes.

INFLUENCE OF RESTRICTED GROWTH RATE AND ELEVATED LEVELS OF MINERALS AND VITAMINS ON FEET AND LEG CHARACTERISTICS, SOUNDNESS SCORES AND FEEDLOT PERFORMANCE IN DEVELOPING GILTS D. F. Calabotta*, G. A. Kesel*, H. R. Thomas, J. W. Knight, H. P. Veit*, D. R. Notter* and E. T. Kornegay. TRCEC, Dept. of Animal Science and Dept. of Veterinary Science, VPI & SU, Suffolk, VA 23437 and Blacksburg, VA 24061

Weaned crossbred gilts (96-six reps of 4/pen/treatment) were used in a 2 x 2 factorial experiment to compare the following treatments: 1) Ad lib intake-NRC daily minerals and vitamins (NRC-MV); 2) 75% ad lib-NRC-MV; 3) Ad lib-150% of NRC-MV; 4) 75% of ad lib-150% of NRC-MV. Feet and leg measurements were taken and lesions, if observed, were characterized at 37, 119 and 185 days of age (73, 48.9 and 92.5 kg). As expected, restricted fed pigs consumed less and gained less. Mineral and vitamin levels had little effect on performance, although pigs fed the high mineral and vitamin levels were slightly more efficient ($P < .05$) overall. Percent horn was lower ($P < .05$) at 119 days of age for the front inside toe and at 185 days of age for the front outside toe for pigs fed the high vs NRC level of minerals and vitamins. The volume of the inside front toe at 119 days of age was greater ($P < .05$) for the ad libitum vs restricted fed pigs. Similar results were observed at 119 days and 185 days for the hind inside toe volume. There were no differences in average front foot score and average hind foot scores for restricted vs ad libitum fed pigs, however, pigs fed the higher vs NRC mineral and vitamin levels had better ($P < .05$) front foot scores.

MOVEMENT AND DISAPPEARANCE OF CAPTAN® AND DIFOLATAN® IN WOODSTOWN LOAMY SAND SOIL. C. W. Conner, R. J. Stipes, R. W. Tillman, and D. F. Anos. Depts. of Plant Pathol.-Physiol. and Agronomy, Virginia Polytechnic Institute and State University, Blacksburg, VA. 24061.

The movement and disappearance of captan (Captan® 50 W) and captafol (Difolatan® 50 W) in a raw, Virginia peanut soil was studied. Vertical movement was monitored by soil column leaching, and disappearance by incubating fungicide-amended soil. Residues were removed from treated soil by solvent extraction, and detected by paper-disk assays on agar plates surface-seeded with *Glomerella cingulata*. When leached with H₂O, both compounds moved into the 10 to 15 cm soil depth, with traces of captan detected in the 15 to 20 cm depth. Movement in all cases was greatly enhanced by leaching with 10% Tween 80. Both compounds disappeared in less than 2 weeks when blended into soil at label rates. At higher application rates, however, the disappearance of captafol was much slower than that of captan. At twenty times the label rate and at 21 C incubation, captan (120 µg/g) disappeared in less than 24 weeks, while captafol at twenty times the label rate (80 µg/g) showed activity after 48 weeks at the termination of the study.

SUPPLEMENTAL BIOTIN FOR SWINE. I. PERFORMANCE, HAIR AND STRUCTURAL SOUNDNESS SCORES FOR DEVELOPING GILTS.

K. L. Bryant, J. W. Knight and E. T. Kornegay. Dept. of Animal Science, Va. Polytechnic Inst., Blacksburg, Va. 24061

Two 20-week feeding trials using 160 gilts were conducted to evaluate the performance of developing gilts fed two levels (0 and 220 µg/kg diet) of supplemental biotin. The gilts averaged 30 days of age and 6.8 kg of weight when placed on trial. A corn-soybean meal basal diet fortified with minerals and vitamins was self-fed. Protein, calcium and phosphorus levels were adjusted according to recent NRC requirements for both levels of biotin as the gilts grew. Gilts were housed in pens with either partial or total slotted floors. The combined data for both trials revealed no difference ($P > .10$) in performance between gilts receiving 0 and 220 µg of supplemental biotin per kg diet. The following performance data were obtained: average daily gain, .57 and .58 kg; average daily feed, 1.59 and 1.59 kg; feed per gain, 2.79 and 2.74, respectively for 0 and 220 µg per kg of supplemental biotin. Subjective hair and structural soundness scores were not different between gilts fed diets with and without supplemental biotin.

DIPEPTIDE, AROMATIC AMINO ACID, AND HEMOPROTEIN LEVELS IN BLOOD PLASMA OF FEEDER STEERS AND DAIRY COWS. G. Colmano, T. E. Lesch*, C. E. Polans*, K. E. Wenz*, Depts. of Vet. Sci., Dairy Sci., and Animal Sci., VPI & SU, Blacksburg, VA 24061

Steer calves were divided in 4 groups of protein supplementation: 1. urea-choline, 2. soybean meal, 3. urea, and 4. soybean meal-choline. Lactating cows were divided in 2 groups: 1. less than 80 days lactation, and 2. more than 80 days lactation, with each group having 2 levels of crude protein and 2 levels of crude fiber. The traditional methods used to determine the nutritional utilization of protein and animal performance were compared to spectrophotometric determinations of blood plasma. The absorption spectra of blood plasma revealed three major peaks respectively associated with dipeptide bonds of protein in the 180-220 nm region, with aromatic amino acid residues at 280 nm, and with porphyrin derivatives from hemoproteins at 414 nm. While the traditional records of average daily gain, total protein, and blood urea nitrogen did not correlate well with the different levels of protein supplementation so far tested, the spectrophotometrically determined peaks in blood plasma followed the utilization of protein supplement fed to the animal, indicating that the higher protein supplementation was followed by a higher protein utilization by the animal. Preliminary studies with a far ultraviolet spectrophotometer indicated increased distinction of characteristic shifts in protein composition, and may allow the study of efficiency of bypassed-protein and microbial protein synthesis.

EFFECTS OF PROGESTERONE/ESTRONE SUPPLEMENTATION ON CONCEPTUS DEVELOPMENT AND LITTER SIZE IN SWINE. D. Lee Dalton, James W. Knight and C. R. Underwood, III. Dept. of Anim. Sci., VPI&SU, Blacksburg, VA. 24061

Following hysterectomy at day 50 of gestation, it was found that gilts which had received exogenous progesterone (P) and estrone (E) between 20 and 30 days of gestation (P/E 20-30) had placentas which were significantly ($P < .01$) longer and heavier than gilts which received P/E from days 4 to 20 of gestation (P/E 4-20) or control gilts which received corn oil (CO) from days 4 to 30 of gestation (CO 4-30). Placentas from P/E 4-20 gilts tended to be heavier than those from controls. Allantoic fluid volume was also greater in those gilts receiving exogenous P/E. These data suggest that exogenous P/E during the first 30 days of gestation had a stimulatory effect on placental development. At day 50, no differences were found in fetal crown-rump length, but fetal weight was greater in the P/E 20-30 gilts. There were no differences in number of live pigs, percent survival, empty uterine weight, uterine length or amniotic fluid volume. Uterine surface area was less ($P < .05$) in the CO 4-30 gilts than in the two P/E groups. Data obtained from 33 gilts similarly treated during early gestation and allowed to farrow revealed no treatment differences for any reproductive performance trait measured at farrowing.

CHANGES IN THE LIPID COMPOSITION OF CONTINUOUSLY CULTURED *CHLORELLA VULGARIS* INDUCED BY THE PLANT GROWTH RETARDANT CYCOCOL. G. A. Davis* and D. M. Orcutt. Department of Plant Pathology and Physiology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

For many plants, Cycocol (2-chloroethyl) trimethylammonium chloride has been shown to increase tolerance to environmental stress. Tolerance to freezing temperatures, high salinity, and drought conditions may be a result of changes in membrane lipid composition. *Chlorella vulgaris* was maintained in continuous culture at a constant cell density. The effect of Cycocol at $1 \times 10^{-4} M$ on the lipid composition of the cells in a steady state condition was determined by gas-liquid chromatography. Treatment resulted in increases in concentrations of phospholipids, triglycerides, free fatty acids, and hydrocarbons. Increases in the total amount of saturated and unsaturated fatty acids occurred with Cycocol treatment. However, a shift in the relative amounts of linolenic acid (18:3), the predominant fatty acid of the control tissue, to linoleic acid (18:2) which predominated in treated tissue, was observed in the phospholipid and free fatty acid classes. Free sterol concentrations were reduced by the treatment.

EFFECT OF ESTROGEN ON LIPOPROTEIN PROFILES OF NON-LACTATING DAIRY COWS. L. F. Ferreri and D. H. Gleeckler. Dept. of Dairy Sci., V.P.I. & S.U., Blacksburg, VA 24060

Estrogen is known to cause alterations in the distribution of serum lipoproteins in rats and man. Evidence from rat studies suggests estrogen modifies the normal catabolism of very low density lipoproteins (VLDL) into low density lipoprotein (LDL). In a preliminary experiment, four non-lactating Holsteins were injected subcutaneously with estradiol-17 β (0.1 mg/kg) for one week. Serum was obtained and lipoprotein profiles generated using agarose gel filtration chromatography. Two of the four cows exhibited marked reductions in VLDL; 23.17% reduced to 4.16%, and 14.41% reduced to 3.16% (expressed as percent total lipoprotein). To obtain sufficient data for statistical validity the experiment was repeated with six additional cows. Unfortunately, little evidence for a reduction in VLDL occurred in these animals. Variations in the physiological status of the six additional animals (age, number of previous lactations, etc.) or variations in experimental procedure (e.g. time of the year) may be reasons for the failure to duplicate our earlier results.

COMPARISON OF DEVELOPMENT OF ROOT-KNOT ON *CISSUS QUADRANGULARIS* AS INFLUENCED BY DIFFERENT METHODS OF INOCULATION WITH A SPECIES OF *MELOIDOGYNE*. Lorraine S. Graney* and L. I. Miller, Dept. of Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Three methods (M1, M2, or M3) of inoculation with a species of *Meloidogyne* were evaluated to determine their influence on galling and egg mass formation on basal stems and roots of *Cissus quadrangularis*. In each method tested, 30 egg masses (EM) were inoculated to a single plant grown in a 4-inch pot of steamed soil. In M1, a rooted transplant was inoculated by distributing the EM to four 1-inch-deep holes in the soil around the basal stem. The inoculum in M2 was introduced into to four 4 mm square by 3 mm deep wounds in the stems a half-inch below the soil line of rooted transplants. In M3, the inoculum was placed at the bottom of a 1-inch deep hole into which a non-rooted stem cutting was planted. The plants were examined for galling and EM development after seven months. Stem galling occurred in M2 and M3 inoculated plants but not in M1 inoculated plants. Galling of the roots was observed in M1 and M3 inoculated plants but not in M2 inoculated plants. EM were not observed in the basal stem of plants inoculated by the three methods although from other experiments it has been learned that they may be formed occasionally in very old infected plants. EM were formed on roots of M1 and M2 inoculated plants but not on M3 inoculated plants. It is concluded that the nematode does not reproduce as readily in stems as it does in roots.

PARASITISM OF THE THISTLE HEAD WEEVIL, *RHINOCYLUS CONICUS*, IN NEWLY-ESTABLISHED AND WELL-ESTABLISHED SITES. P. F. Dowd and L. T. Kok. Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061

Rhinocylus conicus (Froelich) is an imported biological control agent of *Carduus* thistles which has been released in Virginia over a 10-year period. Several native parasites have been found parasitizing this introduced weevil. This study compares the rate of parasitization of *R. conicus* in newly established and well established release sites.

Terminal flower heads (100) of *Carduus nutans* (musk thistle) were collected in late June from each of three release sites, representing recent (3-5 yr), intermediate (6-8 yr) and well established (> 8 yr) weevil populations. Twenty heads per site were dissected soon after collection, and the remaining heads were divided into 4 groups of 20 heads each. Each group was placed in a cloth bag and observed for parasite emergence. All heads were dissected after parasite emergence ceased. Mean rate of parasitization of *R. conicus* larvae in the intermediate site (5.00 \pm 1.78%) was found to be significantly greater ($P < 0.05$) than that of the well established site (2.8 \pm 5.5%) as well as the recently established site (1.2 \pm 1.33%). The latter two sites were not significantly different from each other. The results do not indicate any sustained increase in parasitization of *R. conicus* by the native parasites over the 10 year period. Parasitism (< 10% at all sites) does not appear to be a limiting mortality factor affecting the effectiveness of *R. conicus*.

FLOOR SPACE REQUIREMENT OF WEANED PIGS HOUSED IN A TRIPLE DECK NURSERY. C. L. Gaines*, S. R. Arthur*, K. L. Bryant and E. T. Kornegay. Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

Three trials using 240 crossbred pigs weaned at an average age of 23 days were conducted in an environmentally controlled, triple deck nursery with six, eight or ten pigs per 4 x 4 ft cage (2.7, 2.0 and 1.6 sq ft of floor space per pig, respectively). Pigs housed in the middle deck consumed more feed, grew faster and were slightly more efficient than pigs housed in the bottom deck, with performance for pigs housed in the top deck intermediate. After three weeks, pigs housed ten per cage consumed less feed and grew slower than pigs housed six per cage with feed intake and gain intermediate for pigs housed eight per cage. Feed per unit of gain was similar, although overall, six pigs per cage required slightly more feed per unit of gain. Pigs housed on the upper decks were cleaner with no differences in cleanliness scores among pigs housed ten, eight or six per cage.

SEARCH FOR NUTRIENT RELATIONSHIPS TO SCLEROTINIA BLIGHT AND CYLINDROCLADIUM BLACK ROT DISEASES IN PEANUTS. D. L. Hallock and N. L. Powell, Tidewater Res. and Cont. Educ. Ctr. and Dept. of Agronomy, VPI & SU, Suffolk, Va. 23437 and Blacksburg, Va. 24061.

Soil samples were obtained in 1975 and 1976 from non-diseased areas and areas of peanut fields infected with *Cylindrocladium* black rot (CBR) caused by *Cylindrocladium crotalariae*. Also, soil plus foliar samples were obtained in a similar manner near crop maturity in 1978 from peanut fields infected with CBR and other fields infected with *Sclerotinia* blight caused by *Sclerotinia sclerotiorum*. These soil samples were analyzed for pH and contents of available P, K, Ca, Mg, Mn and Zn and the foliage for contents of P, K, Ca, Mg, Mn, Zn, Cu, and Fe. Analyses of samples from diseased areas were compared with similar analyses of samples from the non-diseased areas in search of possible relationships between nutrient contents and these diseases.

Soil pH averaged slightly higher in CBR-free areas adjacent to infected areas. Average levels of available soil K were 20 to 30 lb/a lower in both CBR and *Sclerotinia*-free areas than adjacent infected areas. Peanut foliage from healthy plants averaged lower in K and Zn, and higher in Mn and Cu than plant foliage from *Sclerotinia*-infected plants. Peanut foliage from CBR-free areas averaged higher in K, Mg, P, Mn, Zn, and Fe than plant foliage from CBR-infected areas nearby.

VIABILITY OF MICROSCLEROTIA OF CYLINDROCLADIUM BLACK ROT FOLLOWING PASSAGE THROUGH THE GASTROINTESTINAL TRACT OF THREE AVIAN SPECIES. R. B. Hiller and P. F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A study was conducted to investigate the possible role of birds in spreading *Cylindrocladium Black Rot* (CBR) of peanuts. Part of the study was to determine the survival of CBR microsclerotia (*ms*) in the avian (Canada Goose, *Branta canadensis*; Bobwhite Quail, *Colinus virginianus*; and Japanese Quail, *Coturnix japonica*) gastrointestinal (GI) tract. Water-suspended *ms* were introduced by intubation into crops of individually housed birds as follows: 100 *ms* in 6 Canada Geese, 300 *ms* in 6 Canada Geese; 5,000 *ms* in 12 Canada Geese, 5,000 *ms* in 12 Bobwhite Quail; and 5,000 *ms* in 12 Japanese Quail. Feces were collected daily over 5 days and cultured to determine viability of microsclerotia following GI passage. In all cases no viable *ms* were recovered. In 15 Canada Geese 5,000 *ms* were given enclosed in porous bags of synthetic material. These were inserted directly into the crops of geese. Bags were recovered from 13 geese as follows: Day 1, 3 intact bags; Day 2, 7 damaged bags, Day 3, 2 damaged bags; Day 4, 1 damaged bag. A total of 5 viable microsclerotia were recovered from 2 of the 3 bags recovered Day 1. The overall results indicate that microsclerotia of CBR fail to survive passage through the avian GI tract. Even when extraordinary efforts were made to protect the *ms* within the GI tract survival was negligible.

BONE CHARACTERISTICS AND FEEDLOT PERFORMANCE OF DEVELOPING BOARS AS INFLUENCED BY RESTRICTED GROWTH RATE AND ELEVATED MINERALS, VITAMINS AND PROTEIN LEVELS. G. A. Kessel, D. F. Calabotta, J. W. Knight, H. P. Veit, H. R. Thomas, D. R. Notter and E. T. Kornegay, Departments of Animal Science and Veterinary Science, VPI&SU, Blacksburg, Virginia 24061

Following necropsy at 10 + 3 day intervals from 80-220 days of age, it was found that restricting the energy intake by 25% that of the full fed animals resulted in the middle metacarpal bone being significantly ($P < .01$) longer. The breaking strength, the fat content of the bone and the percent fat free bone ash tended to be lower in the restricted energy level. In those boars receiving vitamins and minerals elevated to 150% National Research Council (NRC) requirements a significantly ($P < .01$) greater metacarpal bone breaking strength was observed. A significantly higher ($P < .05$) percent fat free bone ash and a lower ($P < .05$) ether extract was also observed in the elevated vitamin and mineral levels.

TESTOSTERONE RESPONSE OF BOARS TO VARIOUS EXOGENOUS HORMONE CHALLENGES AT THREE AGES. H. G. Kattesh, J. H. Knight, F. C. Gwazdauskas, H. R. Thomas and E. T. Kornegay. Depts. of Anim. Sci., VPI&SU, Blacksburg, Va. 24061

Forty-four boars were randomly assigned to one of three age groups (150±7, 200±7 or 250±7 days of age) to examine endogenous testosterone (T) concentrations in response to one of four exogenously administered treatments. Four boars at each age were administered either human chorionic gonadotropin (HCG; 1000 U.S.P. units intravenously), adrenocorticotrophin (ACTH, 100 IU intravenously) or testosterone propionate (TP; 25 mg intramuscularly). The remaining boars were given 0.9% NaCl (S; 5 ml intravenously). Blood was collected from each boar at -120, -90, -60, -30 and 0 min pre-treatment and 15, 30, 45, 60, 75, 90, 105, 120, 150, 180, 210, 240, 270, 300, 330 and 360 min post-treatment via an indwelling anterior vena cava catheter. Plasma T was quantified by radioimmunoassay. Within treatment boars receiving HCG, ACTH or S responded similarly ($P > .10$) across the three age groups for T. Plasma T was elevated ($P < .05$) by 30 min (4.7±.5 ng/ml) and 15 min (5.1±.1 ng/ml) post-treatment in boars given HCG and ACTH, respectively, compared to the S (1.0±.3 ng/ml) group. T in HCG treated boars peaked by 90 min post-treatment, declined slightly until 210 min and increased thereafter. T in ACTH treated boars plateaued by 45 min post-treatment and began to decline by 90 min post-treatment. Plasma T levels for TP treated boars differed ($P < .05$) over time among the age groups.

GOAL PROGRAMMING FOR RESOURCE MANAGEMENT DECISIONS. J. E. Hotvedt* and W. A. Leuschner. Dept. of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Natural resources are usually managed to provide an optimal mix of products and services in the most efficient manner possible. Linear programming has been the prevalent planning technique but has been critically viewed as too restrictive since it implicitly assumes a single objective predominates. Most institutions have many goals and in public resource management the traditional economic objective, maximum net revenue, has a low priority. Furthermore, the linear programming requirement of transforming all resource objectives into one unit, often dollars, has been viewed from impossible to objectionable, particularly for non-market goods such as wildlife or watershed output.

Goal programming has been suggested as a more appropriate allocation technique. Multiple objectives (goals), in different measurement units, may be specified (e.g., elk AUM, recreation user days, or acre feet of water) and the total deviation from these goals minimized. Priorities may be specified for resource uses and trade-offs analyzed.

Goal programming for natural resource management has been applied in multiple-use and timber management in public forestry, public range management, and is currently being applied to industrial forest management.

THE EFFECTS OF DRAINAGE ON A POCOSIN IN ISLE OF WIGHT, VIRGINIA. W.F. Mitchell, S.K. Thomas, and C.D. Peacock, Jr., Dept. of Agronomy, VPI & SU, Blacksburg, Va. 24061. Pocosins are as the Indians described them, swamps, or poorly drained areas of soil on top of a hill. They occur at the highest elevations in Isle of Wight County, ranging from 75 to 85 feet in elevation. Areas are broad and winding and range from 40 to more than 2500 acres in size.

In surficial sediments are relatively old in comparison to surrounding soils, being about 2 million years old, and are fairly deeply weathered with clay enrichment to about five feet. However, soils are generally Typic Ochraqualls and Typic Paleaqualls due to the fact that there is no external drainage from these old marine flats with no drainage-way dissection.

Soils are principally coarse loamy and fine loamy so drainage ditches and agricultural tile is easily installed and maintained. There are fewer limitations on logging practices, longer harvest periods, more opportunities for intense forest management, and field crop production is increased.

PHOSPHORUS AND PROTEIN REQUIREMENT OF DEVELOPING BOARS. E. T. Kornegay and H. R. Thomas. Tidewater Res. Cont. Ed. Center, VPI & SU, Suffolk, VA 23437

Two trials using 192 crossbred boars initially weighing 47 lb were conducted to evaluate diets containing three levels of calcium and phosphorus, National Research Council (NRC), 25% higher and 50% higher, fed in combination with two levels of protein, NRC and two percentage units higher. Average daily gain appeared to be improved initially and feed per gain was lowered when pigs were fed the diet containing 25% higher calcium and phosphorus as compared to pigs fed the diets containing NRC and 50% higher levels. However, during the latter part of the test and overall there were no differences between the various levels of calcium and phosphorus. The effect of dietary calcium and phosphorus levels on pad, feet and structural soundness scores and toe lesions was inconsistent and suggest little, if any, effect on these parameters. Bone ash and breaking strength of the metacarpal were increased linearly as the level of dietary calcium and phosphorus increased. Average daily gain and feed per gain favored pigs fed the higher protein level during the first phase of the test, but were not different during the latter phase. Final pad scores and bone ash were greater for pigs fed the higher protein level. There appeared to be no effect of protein level on soundness and feet scores, toe lesions and bone breaking strength. These results provide little support to the belief that growing and developing boars require higher calcium and phosphorus and protein levels than currently recommended by NRC for market hogs.

ESTRUS DETECTION AND A.I. IN VIRGINIA DAIRY HERDS.

J. A. Lineaweaver* and P. C. Gwazdauskas. Dept. of Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A survey was conducted among Virginia dairy herds participating in the Dairy Herd Improvement Records Program. Responses were obtained from 508 of 846 herds. Daily estrus checking frequency was highest at twice daily for 68.5 percent of the herds while 14.8 percent checked 3 times daily. Fifty-two herds or 12.9 percent checked estrus more than 3 times per day and 4.9 percent used a bull and did not check estrus at all. All herds averaged 2.36 estrus checks daily for an average duration of 15.96 minutes for each check. Overall, 86 percent of all cows and 42 percent of all heifers are bred by artificial insemination (A.I.). A.I. is performed by professional technicians in 47 percent of all herds while dairymen perform 46.3 percent and the dairyman and technician team up for 1.8 percent. Seventy-eight percent of herds breed cows artificially in the morning and/or evening while 28.9 percent reported noon A.I.

ELECTRONIC PREGNANCY DIAGNOSIS IN CATTLE. J. A. Lineaweaver and R. G. Saacke*. Dept. of Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Ninety-four beef cows were checked for pregnancy using the cow preposticator, manufactured by Anamark, Inc. This equipment works on the sonar principle. An external sensor is pressed against the skin in the animal's paralumbar area. Oil is used as an air seal between the sensor and the animal's skin. Small amounts of transmitted energy are reflected from different internal body tissues, collected and displayed on a screen. Rectal palpation was used to age embryos, verify successful breeding dates, and diagnose non-pregnancy. Fifty of 56 cows, pregnant between 30 and 47 days, were diagnosed correctly using the preposticator. Of 22 cows pregnant between 10 and 29 days, 19 were correctly diagnosed. Three cows bred 1 and 2 days were correctly diagnosed as non-pregnant. Thirteen non-pregnant cows were incorrectly diagnosed pregnant. Overall results show 76.6 percent correct diagnosis while 23.4 percent were diagnosed incorrectly.

MATING AND OVIPOSITIONAL STATUS OF ADULT FEMALE CIGARETTE BEETLES KILLED BY DDVP APPLICATION IN TOBACCO WAREHOUSES. J. S. Long, M. H. Tickle*, and M. A. Manzelli. Philip Morris Research Center P. O. Box 26583, Richmond, VA 23261.

The mating and oviositional status of feral cigarette beetle females were studied. Of those females killed by DDVP and collected for examination, 96.3% had mated and the average number of eggs/female was 19.7. One hundred percent of female cigarette beetles collected from black-light suction light traps were not virgin with the average number of eggs/female being 5.3. Live females collected from warehouses and allowed to oviposit in the laboratory produced an average of 43.3 offspring/female. DDVP usage contributes to overall population reduction by preventing young gravid females from infesting the commodity.

COMPARISON OF CHAROLAIS, LIMOUSIN, MAINE-ANJOU AND SHORTHORN BULLS ON SHORTHORN COWS. T. J. Marlowe, E. T. Barnes* and J. S. Copenhaver, Animal Science Department, VPI&SU

Limousin and Maine-Anjou bulls used AI, others naturally as cleanup bulls, except for first year when Shorthorn bull was turned with 15 cows during regular breeding season. Two calf crops (1976-1977) produce 115 calves weaned, with 11 calves lost. Data were adjusted for year, age and sex of calf and age of dam. No. of each kind of calf and LS means are shown in the table.

Sire breed	Calves weaned	Birth weight	Adj ADG	Adj day wt	205 Grade	Cond.
Charolais (C)	21	91.9	2.13	529	13.0	8.3
Limousin (L)	34	79.1	1.97	484	13.0	8.8
Maine-Anjou (M-A)	38	84.6	2.02	499	13.1	8.7
Shorthorn (Sh)	22	78.0	1.82	453	12.2	8.0
Combined	115	82.8	1.99	491	12.8	8.5

Birth wt was signif lower for Sh sired calves and highest for C sired calves, with L and M-A calves intermediate. ADG and wmt followed the same pattern as birth wt. M-A sired calves av. 15 lb heavier than L sired calves, but 30 lb lighter than C sired calves. No diff in grade of C, L or M-A sired calves, all of which av. about one grade point higher than Sh sired calves. When all XB's were compared to all SB calves, diff were 7.2 lb at birth, .22 lb ADG, 51 lb wmt, .8 grade point and .6 cond score in favor of XB calves. M-A matings produced 5 percentage point more calves weaned than L matings (67.7 vs 62.7%).

COW BREED EVALUATION IN THE SOUTHAMPTON HERD. T. J. Marlowe and W. E. Burgess*, VPI&SU, Blacksburg, and Southampton Correctional Center, Capron, Virginia

Heifers were exposed to Angus (A) bulls 75 days annually (1971-75) as yearlings or 2-yr-olds, except Char (C) were bred to C bulls. After first calving, all were exposed to Sim x Her (SH) bulls for 75 days each in 1972-77, except C and half of A cows were exposed to bulls of their own breed. Data were analyzed separately for heifers and cows by LS procedures. Model included effects of year, sex, age and breed of cow, and interactions of BxY and BxS. Number of each kind of cow exposed, along with % calf crop and performance data to weaning, are shown in table. Ax indicates A cows bred first to A bulls and thereafter to SH bulls.

Br of cow	Heifer performance				Cow performance					
	No. exp	% wean	W,wt (lb)	lb ca/Gr C exp	No. exp	% wean	W,wt (lb)	lb ca/Gr C exp		
AA	30	73.3	372	11.1	273	118	83.9	412	12.4	348
CC	39	59.0	481	12.5	284	100	71.0	521	13.2	391
CA	33	72.7	372	11.1	270	125	82.4	444	12.4	366
CA	44	70.4	410	12.2	289	125	89.6	479	13.1	429
FA	42	88.1	443	12.1	390	129	89.9	514	13.2	473

Breed of cow diff. were signif. for ADG, W,wt and grade but not for age or cond. at weaning. Crossbred (XB) cows weaned 10 more calves and 7,700 lb more calf wt per 100 cows exposed than did the straightbreds (SB). Among XB matings, FA cows weaned 53 lb more calf than CA cows and 99 lb more than AA cows producing XB calves. Calf grades also favored XB and C cows.

COOPERATIVE BEEF CATTLE BREEDING RESEARCH. T. J. Marlowe and R. C. Oliver*, VPI&SU, Blacksburg, and Department of Corrections, Richmond

A cooperative cattle breeding research project was initiated between the Animal Science Department of VPI&SU, Blacksburg, and the Department of Corrections, Richmond, in 1968 to: 1) evaluate several breeds as sire breeds; 2) compare several kinds of XB and SB cows produced in obj. 1; and 3) determine best comb. of breeds and mating schemes for maximizing production. In phase I, eight sire breeds were evaluated and those findings reported at earlier meetings. In phase II, 3 SB and 9 XB cow types were evaluated at five locations. Results of cycles 1 and 2 are reported here for 3 of the 5 herds involved. Detailed results are reported in the following abstracts. In general, XB cows were superior in fertility, calf mortality, and lb calf produced. Unweighted averages over all locations for XB vs SB cows were 12.5 vs 15.4% for open cows, 8.6 vs 12.7% for calves lost, 79.0 vs 73.5% for calves weaned and 377 vs 295 calf weaned per cow exposed. Calves out of XB cows also graded 1/3 USDA grade higher. Holstein X (either FA or FH) cows were the top performers at all locations. Corresponding values for FH cows were 10.4%, 7.9%, 83.9%, and 410 kg calf per cow exposed. When Best XB cows were compared to SB controls, diff ranged from 32 to 147 lb, av. 113.1 lb over all 5 locations. For the 1978 calf crop the diff amounted to 126,429 lb extra calf at wt; valued at \$120,107.55 at present market prices.

COW BREED EVALUATION IN THE BEAUMONT HERD. T. J. Marlowe and E. S. Straderman*, VPI&SU, Blacksburg, and James River-Powhatan Correctional Center, State Farm, Virginia

During 1973-75, 150 heifers of Char x Her (CH), Hol x Her (HH), Short x Her (SH) and Her (HH) breeding calves as 3-yr-olds. All heifers were exposed to Angus (A) bulls for 75 days annually and thereafter to A or Sim x Ang (SA) bulls thru the 1978 crop, except that half of the HH heifers and cows were bred to H bulls. Data were analyzed separately for heifers and cows by LS procedures. The model included effects of year, age and breed of cow, sex and BxY and BxS interactions. Hx indicates HH cows bred to produce XB calves.

Heifer performance				Cow performance				
No.	%	W.wt	lb ca/	No.	%	W.wt	lb ca/	
exp	wean	(lb)	Gr C exp	exp	wean	(lb)	Gr C exp	
CH	27	66.7	430	12.8	287	103	70.9	466
HH	25	84.0	470	13.0	395	101	77.2	491
SH	24	79.2	410	13.0	325	108	84.2	446
Hx	23	69.6	361	11.1	251	100	62.0	376
HH	27	77.8	341	10.9	265	129	74.4	374

Cow breed diff. were signif. for ADG, W.wt, grade and cond. but not for calf age. XB cows weaned 71 lb more calf per cow exp. from heifers and 83 lb more from cows or 81 lb more over 5 seasons than SB. Corresponding XB-Hx were 85, 132 and 121 lb, resp. XB cows ranked (H to L), FH, SH and CH. FH cows weaned 10.4 more calves and 10,700 more lb calf per 100 cows exposed than did HH cows. Offspring of XB cows graded 1/3 USDA feeder grade higher than offspring of SB cows.

COW BREED EVALUATION IN THE STATE FARM HERD. T. J. Marlowe and E. S. Straderman*, VPI&SU, Blacksburg, and James River-Powhatan Correctional Center, State Farm, Virginia

Seven kinds of cows were compared in 1975-78, Ang x Her (AH), B. Sw x Her (BH), Char x Her (CH), Hol x Her (HH), Sh x Her (SH), Sim x Her (SH), and Her (HH). 427 2-yr-olds were exp. to A bulls (except AH cows exp. to S and half HH cows to H bulls) for 75 da annually. Thereafter, all cows bred to S bulls (except SH cows bred to A bulls and half HH cows to H bulls). Data analyzed separately for heifers and cows by LS procedures. Model included year, cow breed, sex, BxY, BxS and cow age. Nos. and LS means are shown in table.

Heifer performance				Cow performance				
No.	%	W.wt	lb ca/	No.	%	W.wt	lb ca/	
exp	wean	(lb)	Gr C exp	exp	wean	(lb)	Gr C exp	
AH	59	79.7	403	12.0	321	92	75.0	436
BH	46	84.8	451	11.9	382	59	72.9	467
CH	54	75.9	429	12.7	326	89	70.8	464
FH	60	89.3	468	13.0	418	92	80.4	479
SH	43	90.7	418	12.2	379	66	74.2	444
SH	51	80.4	422	12.6	339	85	74.1	446
Hx	55	76.4	378	11.9	289	107	81.3	411
HH	59	66.1	380	11.6	251	74	75.7	364

XB cows weaned 7 more calves than av. 75 lb more than SB calves and 46 lb more than XB calves out of SB cows. FH cows superior to all others, weaning 132 lb more than SB matings, 79 lb more than SB cows with SB calves and 39 lb more than closest competitor (BH).

PLANT POPULATION AND PLANTING CONFIGURATION EFFECTS ON INSECT POPULATIONS IN ESSEX SOYBEANS. J. M. Murphy and J. C. Smith,* Dept. of Entomology, V.P.I. & S.U., Blacksburg, Va. 24061

Essex variety soybeans were planted July 5, 1978 in 12, 24 and 36 inch row spacings. Within each row spacing were populations of 1, 2 or 4 plants per square foot corresponding to 43,560, 87,120 and 174,240 plants per acre, respectively. Weekly shake cloth observations revealed that 36 inch row spacings had significantly higher numbers of predaceous insects and the green cloverworm, *Plathypena scabra* (F.). There were no differences in numbers of phytophagous insects in plant populations of 1, 2 or 4 plants per square foot. There were higher numbers of predaceous insects and green cloverworms in populations of 4 plants per square foot, but they were not significantly different from those found at 2 plants per square foot. Generally, highest numbers of phytophagous and predaceous insects were found in those planting configurations with the widest row spacings and densest plant populations within the rows.

COMPARISON OF RANDOM AND SELECTED SITES FOR THE CULLEN SERIES IN GREENSVILLE COUNTY. C.D. Peacock, Jr., A.C. Blackburn, and W.J. Edmonds, Dept. of Agronomy, VPI & SU, Blacksburg, Va. 24061

A comparison of the means of selected pits versus random sites of the Cullen Series was made to determine the significance, if any, of the characteristics used to classify the soil. The characteristics used to evaluate the means were percent clay, silt, silt plus very fine sand, and sand from the particle size control section and solum thickness. The evaluation was based on six selected pits and twenty three random site samples. A SINGLE CLASSIFICATION ANOVA WITH UNEQUAL SAMPLE SIZE was used to determine the significance of the means at the 90 percent confidence level. The two methods were found to be not significantly different although the random sites method established a more narrow range at one standard deviation.

POPULATION DENSITIES OF PLANT PARASITIC NEMATODES IN AGRICULTURAL SOILS OF SOUTHEASTERN VIRGINIA. P. M. Phipps* and J. A. Fox, Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

In October 1978, 376 soil samples from approximately 1500 acres in Southampton County, Isle of Night County, and the City of Suffolk were analyzed for plant parasitic nematodes. Each soil sample was composed of 25 to 30 systematically collected soil cores (2-cm thick x 15- to 20-cm deep) from the plow layer in a 4-acre block of land. Nematode assays were performed by the elutriation-centrifugal flotation method. Using a threshold level of 25 nematodes per pint of soil, the 205 samples from soil planted to corn in 1978 showed 81% with Stunt nematode, 38% with Root Knot nematode, 35% with Ring nematode, 19% with Lesion nematode, 11% with Stubby Root nematode and less than 10% with various other nematodes (Lance, Spiral, Dagger). The 110 samples from soil planted to peanut in 1978 showed 89% with Root Knot, 56% with Stunt, 50% with Ring, and less than 10% with various other nematodes (Spiral, Lance, Lesion, Dagger, Stubby Root, Sting). The 23 samples from soils planted to soybeans showed 74% with Stunt, 70% with Root Knot, 40% with Spiral, 35% with Ring, 22% with Stubby Root, and less than 10% with various other nematodes (Dagger, Lance, Cyst, Lesion). This survey represents the initial stage of a long-range study to assess needs for nematode control in field crops.

SIMULATING THE SPREAD OF SOUTHERN PINE BEETLE INFESTATIONS. D. D. Reed*, H. E. Burkhardt and W. A. Leuschner, Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

A model has been developed to simulate the rate of spread of southern pine beetle (*Dendroctonus frontalis*, Zimm.) (SPB) infestations. The model has two principal functions: (1) a function to predict the number of trees killed per day, and (2) a function to predict the probability of the infestation becoming inactive. Spot growth through time can be simulated with these two relatively simple functions.

A FORTRAN program was written for this model and was tested with data collected from eleven independent sample SPB spots. There were 270 trees killed on the independent sample plots over a period of approximately 120 days from June to October. The average of ten simulation trials was 252.6 trees killed. Thus, the simulation program predicted 6.45% fewer trees killed than was observed in the test data. The observed number of trees killed in the test data was within the range of the predicted values from the ten simulation runs.

EFFECT OF SULFUR APPLICATION ON CORN YIELD AND COMPOSITION. R. B. Reneau, Jr. Department of Agronomy, VPI & SU, Blacksburg, Virginia, 24061.

Field experiments with corn (*Zea mays* L.) were conducted during the past two years to evaluate growth as influenced by S application. During this time when responses to S were measured, the soil extractable S level in the surface horizons was below 25 Kg/ha and adequate subsoil S, if present, was not available. Increased yields with S application occurred in coarse-textured soils and in soils where root penetration into the subsoil was inhibited. Both chemical and physical inhibition of roots into subsoil materials have been observed in 1977 and 1978. Sulfur responses appear to be enhanced by moisture stress and probably results from limited root proliferation during these periods. Increased yields ranged from 15 to 40 percent.

Chemical composition of the tissue has shown that protein N was not affected, but S and N to S ratios changed significantly. These changes in S and the N to S ratio in the tissue also appears to be related to time of sampling (days after emergence).

FACE FLY AND HORN FLY CONTROL BY MEANS OF BACKRUBBERS. J. E. Roberts, Sr. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

The purpose of this test was to measure the effectiveness of Ravap insecticide and Cow Life-Cattle Rub backrubbers with face flaps attached.

The treated herd was subjected to forced treatment in that the cows had to go under the backrubbers with the fly flaps attached to obtain mineral. Backrubbers with attached fly flaps were placed across the entrance to a small pen. A mineral box was placed inside the pen. The cows treated themselves as they passed under the self treatment device to obtain mineral.

Horn fly counts were based on the actual count of Horn flies on one side of the animal, multiplied by two for the total number per animal. Face fly counts were confined to the actual number of flies on the face of the animals. Both face and Horn fly counts were made with the aid of binocular field glasses.

Ravap on Cow Life-Cattle Rub backrubbers with face flaps gave poor control of Face flies and good to excellent control of Horn flies during this test.

CHEMICAL CONTROL OF HOG LICE. J. E. Roberts, Sr. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

A test demonstration for control of hog lice was conducted in Buckingham County, Va., from June to August of 1978 on Yorkshire and Hampshire brood sows. This test compared Starbar CX 118 (Prolate) to pretreatment counts and untreated check animals.

Two rates of this insecticide (1 to 2 parts H₂O and 1 to 5 parts H₂O) were applied as a pour-on. Animals were treated along the backline from the hips to the neck area. Approximately 1 oz./100 lbs. body wt. was applied to each animal by means of a calibrated dipper.

Excellent control was obtained for a period of three weeks with both rates. The cooperator was well pleased with the results of this material. There were no adverse effects on the animals or the applicator.

FACE FLY AND HORN FLY CONTROL WITH RABON ORAL LARVICIDE ADDED TO MINERAL MIXTURE. J. E. Roberts, Sr., and H. J. Gerken, Jr. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

The purpose of this test was to measure the effectiveness of Rabon Oral Larvicide in the control of flies on cattle.

Four similar herds of Angus, Herefords, and Shorthorn crosses were selected; two at site A and two at site B approximately 10 miles apart. One was used as a control herd and one was treated with Rabon Oral Larvicide as a mineral additive at each test site. Seven post-treatment counts were made at site A and ten post-treatment counts at Site B. The test herd at site A consisted of 46 animals. The test herd at site B had 101 cows and the control herd had 20 cows and their calves.

Horn fly counts were based on the actual count of horn flies on one side of the animal and multiplied by two for the total number per animal. Face fly counts were confined to the number of flies on the face of the animals. Both Face and Horn fly counts were made with the aid of binocular field glasses.

Rabon Oral Larvicide gave poor control of both Face and Horn flies in these tests.

FACE FLY AND HORN FLY CONTROL BY MEANS OF RABON IMPREGNATED EAR TAGS. J. E. Roberts, Sr., and W. H. McClure. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

The purpose of this test was to measure the effectiveness of Rabon ear tags for the control of face flies and horn flies on cattle.

Two similar herds of Angus-Herefords and Shorthorn crosses were selected; one to be used as a control herd; one to be treated with Rabon ear tags, one in each ear of the test animals. Eight post-treatment counts were made. There were 36 animals in the test herd and 63 animals in the control herd.

Horn fly counts were based on the actual count of horn flies on one side of the animal, multiplied by two for the total number per animal. Face fly counts were confined to those around the eyes and nose of the animal. Ten animals per herd for counts were considered adequate representation of the herd.

Rabon ear tags showed variable efficiency throughout the test and gave better control of horn flies than face flies.

DEVELOPMENT OF ARTIFICIAL DIETS FOR REARING BENEFICIAL INSECTS. D. J. Rowe and L. T. Kok. Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061.

The development of artificial diets for rearing insects has increased significantly during the past few decades. This has partly been in response to the demand for large numbers of insects required in various aspects of pest management and research. Insect colonies may be reared and studied in a limited amount of space throughout the year yielding specimens of uniform age and quality. A thorough understanding of insect nutrition is essential to the successful formulation of an artificial diet. It must possess all the vital nutrients in the correct proportions needed for normal growth, development and reproduction of that species.

The presence of certain non-nutritive factors play key roles in the host selection and specificity of many insect species. Chemical components of the host often act as attractants and/or phagostimulants. Physical characteristics such as texture, shape and water content also affect induction and maintenance of feeding.

Virtually all of the outstanding results from introductions of beneficial insects for pest control have been achieved by highly host specific natural enemies. This attribute largely determines an insect's biological control potential, but also makes it much more difficult to mass produce. Efficient propagation of these insects cannot be easily accomplished until determinations of all requirements (both nutritional and otherwise) are made and successfully incorporated into a laboratory rearing program.

PHEROMONE TRAPPING FOR CLEAR-WINGED BORER PESTS OF WOODY ORNAMENTALS IN VIRGINIA. P. B. Schultz and L. A. Parnell Virginia Truck & Ornamentals Research Station, Va. Beach, VA 23455.

Pheromones offer an inexpensive and simple method of monitoring clearwing borers. The use of the pheromones in conjunction with sticky traps provides information on pest abundance and life history for the attracted species. In 1978 pests monitored with the attractant *cis*, *cis*-5,13-octadecadien 1-01 acetate, were the dogwood borer, *Synhedon scitula*; oak borer, *Paranthrene simulans*; and lilac borer, *Podessa syringae*.

Trap collections indicate dogwood borer emergence occurred from May to early October in eastern Virginia. A total of 164 males were collected from a site in Chesapeake, Virginia; substantially fewer males were collected at the other sites. The variation may be the result of impure pheromone or of different population levels of dogwood borer at each site. Suppression measures for this species should begin in late May and continue through October.

Emergence of the oak borer occurred from late May to mid-June in all regions where the insect was trapped. This species would require only one treatment in early June for its suppression.

Lilac borers were collected from mid-May to mid-July at all trap sites in Virginia. Suppression measures for this species should begin in May in eastern Virginia and in June in the remainder of the state.

CARDUUS THISTLE RESPONSE TO ATTACK BY PHYTOPHAGOUS INSECTS. P. J. Sieburth and L. T. Kok. Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061.

The impact of insects attacking agricultural crops has been well documented, but the impact of phytophagous insects in restricting growth of unwanted plants has received less attention. Two biological control agents of *Carduus* thistles (noxious weeds) have shown plant responses which vary with the level of infestation. *Rhinoecylus conicus* Froelich, a weevil whose adults feed on thistle leaves and whose larvae feed within the thistle blooms, mainly restricts seed production at low levels of infestation. At high levels of infestation, the infested blooms are aborted with no seeds being produced. No secondary blooms are given off as a result of destruction of the terminal blooms.

Ceuthorrhynchidius horridus (Panser), a weevil attacking the base of the thistle plant, mainly affects the meristematic tissues which are fed upon by the larvae. At high levels of infestation the growth point is initially destroyed. This subsequently results in the death of the plant. However, at low levels of infestation, new shoots are frequently produced despite death of the growth point. This response is also influenced by plant vigor. Highly stressed plants do not often recover, but vigorous plants are capable of recovery.

COMPARISON OF THREE FLOORING MATERIALS FOR WEANED PIGS HOUSED IN A TRIPLE DECK NURSERY. H. R. Thomas and E. T. Korngay. Tidewater Res. Cont. Ed. Center, VPI & SU, Suffolk, Va. 23437

Three trials using 312 crossbred pigs averaging 15.5 lb were conducted to evaluate the performance and feet pads of weaned pigs housed in triple deck cages in which three types of floors were used: .38 x 1.5 in galvanized woven wire, .75 x 1.5 in galvanized flat expanded metal and .5 x .5 in oil tempered wire cloth (quarry wire). Eight pigs were housed per cage (2 ft² floor space per pig). A 20% crude protein corn-soybean meal diet with 10% dried whole whey was fed until the average pen weight reached 25 lb and then an 18% diet without whey was fed to the end of test. The trials continued for either 42 or 49 days with an average final body weight of 48.8 pound. Average daily gain, feed intake, feed per gain and pad scores were not different ($P > .10$) between pigs housed on the bottom, middle and top decks. There were no differences ($P > .10$) in average daily gain, feed intake and feed per gain between pigs housed in cages with woven wire, expanded metal and quarry wire. However, pad scores were higher ($P < .05$) indicating more cuts and abrasions for pigs housed in cages with quarry wire as compared to pigs housed in cages with woven wire and expanded metal.

EVALUATION OF TECHNIQUES USED FOR THE SIMULTANEOUS EXTRACTION AND ANALYSIS OF GIBBERELLIC AND INDOL-3-ACETIC ACID FROM SOYBEAN TISSUE. D. G. Shilling* and D. M. Orcutt. Dept. of Plant Pathology and Physiology, VPI&SU, Blacksburg, Va. 24061.

The procedures (PI,PII,PIII) were evaluated to determine the best method for simultaneously extracting gibberellic acid (GA_3) and indole-3-acetic acid (IAA) from Glycine max (L.) Merr. All procedures utilized solvent partitioning for purification of plant extracts, but differed in extraction solvents, pH at which partitioning was carried out and chemicals used to adjust pH. Gas-liquid chromatography (GLC) was used to determine recovery and extraction efficiency of GA_3 and IAA.

Optimum conditions for maximizing recovery of IAA and GA_3 were determined prior to a comparison of the three procedures. Recovery of IAA and GA_3 was found to be enhanced by the addition of antioxidant and careful manipulation of evaporation steps. Internal standards were run for all three procedures both in the presence and absence of tissue. Tissue was also run through each procedure without added standard (Blank). In all cases, the presence of tissue resulted in lower recoveries of internal standards. The best recovery of internal standard in the presence of tissue occurred with PIII (88% IAA and 61% GA_3). The most efficient solvent for extracting endogenous IAA was methanol; yielding 9 μ g IAA/g dry weight of tissue. No GA_3 was detected in any of the blank tissue samples analyzed.

INSECT CONTROL ON PEANUTS BY PLANTING AND PEGGING APPLICATIONS. J. C. Smith. Tidewater Res. and Cont. Ed. Ctr., VPI & SU, Suffolk, Va. 23437.

Insect controls and damage ratings were made on Floripant var. peanuts treated with various soil-applied systemic and foliar spray insecticides. Tobacco thrips, *Frankliniella fusca* Hinds, were controlled by Dacamac 15C @ 2.0ppb, Standak 75W @ 1.5 ppb, Disyston 15C @ 1.0 ppb and Azodrin 5 @ 1.0-spray. Those same treatments plus Dacamac 15C @ 1.0 ppb and Temik 15G @ 1.5 ppb allowed less thrips reproduction.

Potato leafhoppers, *Empoasca fabae* (Harris), were most numerous on plots treated with the fungicides, Bravo and Copper Count N. Temik, Dacamac, Thimet, Nemacur and Nematak gave perfect early control. Dacamac gave nearly perfect control through August 21. The foliar sprays, Lannate, Sevin, Vydate and Azodrin were excellent treatments.

Southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber, injury was severe. No soil-applied systemic significantly reduced injury over the control. Three spray applications of Lorsban gave best control in one test. Temik in-the-furrow plus Standak at pegging allowed the least injury in a second test.

Yield and value was significantly higher than the control from a split application of Temik, a split Temik plus Standak treatment and the Azodrin foliar treatment. Although not significantly different, the Lorsban spray treatment gave a value increase of \$142.37/acre. This increase probably expressed the value of rootworm control.

USE OF COMPUTER GAMES IN TEACHING PEST MANAGEMENT. Ronald W. Tillman. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ. Blacksburg, Va. 24061

Pest management students must integrate various control methods into workable programs that are used to manage a range of pests. Because of time and resource limitations it is not possible to involve students in field experiences that enable them to practice problem solving and decision making. To overcome these limitations interactive computer simulations (didactic games) are being employed. Based on biological data, the games mimic realistic crop-pest situations and enable students to practice making critical decisions without jeopardizing the commodity or environment because of a bad decision. The games have four major sub-models: a weather generator; a commodity growth model; a pest development model and a pesticide attenuation model. Depending on the initial parameters chosen to drive the sub-models a variety of learning objectives is possible. Some of these objectives are the influence of weather on pest development and control, the interaction between biological, cultural and chemical control methods, the influence of one seasons pest control on subsequent pest levels, and the influence of economics on control decisions. Identical conditions can be duplicated in successive plays so that students can repeat situations and logically correct their mistakes. Because the games are independent of the time of years students can experience several growing seasons in a short period of time at much less expense than on-the-job training.

THE USE OF PRESENT NET WORTH MODELS IN ESTIMATING THE ECONOMIC IMPACT OF SOUTHERN PINE BEETLE (*DENDROCTONUS FRONTALIS*, ZIMM.) ON TIMBER RESOURCES. F. C. Walters* and W. A. Leuschner, Dept. of Forestry, VPI & SU, Blacksburg, VA 24061.

Forest resource managers need an operational procedure to accurately determine Southern Pine Beetle's (SPB) economic impact on timber to establish control decision guidelines. Benefit cost analysis provides a reliable framework. The control program's benefits are estimated along with costs to determine the difference in discounted net worth of a timber stand with and without a control program. Program implementation is indicated if the PNW difference is positive.

A study was undertaken to estimate the potential timber benefits associated with SPB attack. The model was operationally tested on a regional scale involving several landownership classes in Central Mississippi. A sensitivity analysis was then conducted on the individual input components within the model to ascertain their effect on total timber damage estimates. No attempt was made to identify or estimate the costs associated with SPB control.

PREDICTION EQUATIONS BASED ON RELATIONSHIP BETWEEN A DAM'S PERFORMANCE TRAITS AND THE WEANING WEIGHT OF HER PROGENY. W. H. Whittle, Jr.* and T. J. Marlowe, Animal Science Department, VPI&SU, Blacksburg, Virginia 24061

Data on 176 cows produced in 1970-75 and their 532 offspring produced in 1972-77 were analyzed by LS procedures to adjust for effects of year, season, sire breed, dam breed, age and sex of calf (except for dams) and age of dam. Dam's performance traits (weight, grade and condition scores) at weaning, 12 and 18 mo were then correlated with offspring weaning weight. Data were subdivided into four sets: I = 1st calf only, II = 1st and 2nd calves, III = all calves, and IV = same as III except records were adj. by Va BCIA factors. Weaning weights in data sets II, III and IV were converted to MPPA values for the correlation analyses. Prediction equations for expected progeny weaning weights were calculated by using residuals of the dam's performance traits thru a set of stepwise regressions called Max R² Improvement. In set I, 18 mo condition gave highest correlation ($r = .24$). In set III, largest r came from 12 mo weight (.15) and 18 mo weight ($r = .18$). r values in set IV were generally lower and nonsignificant. All traits combined account for no more than 10% of variables in weaning weight. In general, these analyses indicate that prediction equations for weaning weight from dam's performance traits are of limited use as selection tools.

Astronomy, Mathematics, and Physics

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

THE USE OF βX IN ABSOLUTE C^* -EMBEDDING THEOREMS.

C.E. Aull, Department of Mathematics, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

A property P is the (closed) C^* -embedding absolute of a property Q if a space X having property Q is C^* -embedded in every space having proper Q it is embedded in (as a closed set) iff X has property P . A technique involving quotients of subsets of βX is used in connection with the closed C^* -embedding absolutes for metacompact spaces, P -spaces and Z -spaces.

THE MICROCOMPUTER AND MINICOMPUTER IN A PHYSICS OF MUSIC

COURSE. L. N. Beard, Dept. of Physics, Hampden-Sydney Col., Hampden-Sydney, Va. 23943.

An MMD microcomputer (8080-based) has been equipped with inexpensive A/D and D/A converter circuits for use in a Physics of Music course for non-majors. The analog-to-digital converter has a maximum sampling rate of one 8-bit word per 45 microseconds, which permits digitizing of audio frequency waveforms. (At this sampling rate, 256 points are sampled in about 0.01 sec.; this typically corresponds to 2-4 cycles of a musical instrument waveform.) The data can then be transmitted to a minicomputer (a PDP-11) for harmonic analysis. Waveform synthesis can also be performed using software in the minicomputer. Such waveforms are transmitted to the microcomputer and its D/A interface for graphical or audio output. Other applications, such as studies of filter response, etc., will also be described.

THE APPLICATION OF CATASTROPHE THEORY TO NONLINEAR

OSCILLATORS. A.M. Buoncristiani¹ and G.R. Webb. Dept. of Physics, Christopher Newport College, Newport News, VA 23606.

A new approach to the problem of modeling phenomena displaying a discontinuous behavior or an abrupt change in state has been developed by the French topologist Rene Thom. This approach, which Thom calls the theory of catastrophes, is an outgrowth of the study of stability of dynamical systems. The theory provides a different conceptual understanding of a phenomenon by presenting a simple global perspective of it.

Physical realizations of nonlinear oscillators often display the discontinuous behavior that characterizes systems that are amenable to description by catastrophe theory. Here we examine the limit cycle behavior of systems undergoing approximately sinusoidal oscillations. We show how the theory of constrained catastrophes can be used in obtaining the full unfolding of a differential representation of the system, and in constructing a differential equation to serve as a model of the system if only experimental data on the intensity surface for the system is known.

We illustrate the theory by its application to a van der Pol oscillator. (Aided by NASA grant NSG-1429).

SIMPLE PHYSICS DEMONSTRATIONS. D. R. Carpenter, Jr. and R. B. Minnix. Dept. of Physics, VMI, Lexington Va. 24450.

Summer short courses on demonstrations held at VMI attract teachers from across the nation. Demonstrations using the simplest of equipment continue to have the highest appeal. Six from recent short courses include a baking powder can explosion using natural gas, a small neon or argon bulb and a red-green diode rotated in a circle to illustrate the alternating nature of household voltage, and the effect of front vs rear wheel skidding on a model car.

Also the change in resonant pitch of a plastic soda straw as a reed pipe when its length is shortened, the "burping" of a chilled Coke bottle as it warms up with its opening partially blocked by a dime, and the regelation of water using a "C" clamp to apply pressure on ice in a brass cylinder.

ANALYSIS OF AN INHERENT LIMITATION TO COMPUTER PROGRAMS.
Arthur Charlesworth, Dept. of Mathematics, University of
 Richmond, Richmond, Va., 23173

Consider the following variant of A.M. Turing's Theorem: no BASIC computer program can determine whether or not any given BASIC program, run with any given set of data, will go into an infinite loop. We observe that any sufficiently powerful programming language can be substituted for BASIC in this Theorem, without having to assume Church's Thesis, if we assume instead the following proposition: any programming language which is powerful enough to check programs for infinite loops must also allow statements which can be combined to form an infinite loop. This proposition would be false if it is possible to develop a programming language that is powerful and that, in addition, incorporates a clever new kind of loop structure which guarantees that all loops terminate.

As evidence for the proposition, we have the following result: Let \mathcal{L} be a programming language which is powerful enough to write (1) an \mathcal{L} -syntax checking program, (2) an \mathcal{L} -interpreter, and (3) a program which, given a string S and a natural number n as data, generates all strings of length $\leq n$ whose characters belong to S ; then \mathcal{L} must allow statements which can be combined to form an infinite loop.

A TRANSISTOR CURVE TRACER EXPERIMENT IN ELECTRONIC INSTRUMENTATION. F. P. Clay, Jr., C. E. Rash*. Dept. of Physics, Old Dominion Univ., Norfolk, VA 23508

An instrument for plotting a family of characteristic curves for a transistor can be implemented by a synthesis of circuits frequently studied in an electronics laboratory course. The output from the circuit uses either an x-y recorder or an oscilloscope in the x-y mode to display the data.

The instrument consists of a function generator, stair-step generator, driven constant current generator as well as summation amplifiers. Each sub-circuit is studied and tested using integrated circuits to implement the designs. These sub-circuits are part of the laboratory work in the early portions of the course.

The curve tracer experiment is used to demonstrate the interface problems that must be solved whenever an instrument is synthesized from sub-circuits.

SOME MAPPING CHARACTERIZATIONS OF TOPOLOGICAL PROPERTIES.
R.F. DICKMAN, JR.* Dept. of Math., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

In this paper the author employs the techniques of analytic topology to resolve a thirty year old conjecture of Arthur H. Stone. The technique suggests that other problems of continua theory may be similarly examined.

Several related results and questions are presented.

FREE EDDIES IN A STREAMING STOKES FLOW. J. M. Dorrepaal. Department of Mathematical and Computing Sciences, Old Dominion University, Norfolk, VA 23508

The uniform streaming Stokes flow past two equal separated cylinders is considered where the direction of flow is perpendicular to the line joining the centers. Because of Stokes paradox, the problem reduces to solving for the first term of the inner expansion for low Reynolds number flow past two cylinders. It is found that fluid always moves through the gap separating the two cylinders no matter how small it is. When the gap width is less than 0.0446 times the cylinder radius, two free eddies form along the center line, one on either side of the gap. These eddies are completely isolated from the cylinder boundaries by the surrounding fluid and their appearance is a Stokes flow phenomenon not observed before. For smaller gaps both free eddies and boundary eddies are present. These interlace as the cylinders approach forcing the fluid which moves through the gap to take a winding path.

LASER EXCITED PHOTOACOUSTIC/OPTICAL ABSORPTION KINETICS IN II - VI SEMICONDUCTORS. G. W. Edwards* and R. W. Major. Dept. of Physics, Univ. of Richmond, Va. 23173.

Low-power millisecond laser pulses incident on ZnSe:Cu generate electron-hole pairs, modulating the absorption of a monochromatic probe beam incident on the sample at 90° to the laser beam. The observed signal fails to yield the kinetics of the optical excitation sought, because its shape is modified by a bulk heating effect.* We are applying the techniques of photoacoustic spectroscopy (PAS) in experiments designed to resolve this thermal contribution, whose removal from the overall absorption kinetics is expected to yield the purely optical excitation.

*R. W. Major and K. L. Elledge, J. Phys. Chem. Solids **19**, 971 (1978)

FRANCK CONDON FACTORS AND R-CENTROIDS FOR SIX DIATOMIC MOLECULES. P.M. Fazio*, and G.E. Copeland. Dept. of Physics, Old Dominion University, Norfolk, Va. 23508

The Franck Condon factor is defined as the square of the overlap integral and is so named because of its ties with the Franck Condon Principle. The r-centroid is the inter-nuclear separation associated with the electronic transition of a diatomic molecule. The physical meaning of these integrals are discussed. The construction of the wavefunctions, for two methods, are presented. Both methods employ the Morse Potential Energy function. The first method calculates the integrals using the analytic wavefunction of Morse and the second method has numerically constructed wavefunctions. Six molecules are studied; AsO, MgF, SrH, NO⁺ CO⁺ and N₂. The results are compared with published results of other methods. The electronic states are B²Σ⁺ to x²Σ⁺ for AsO, A to X for NO⁺, C²Π_u to B²Π_g for N₂, A²Π_g to X²Σ⁺ for CO⁺, A²Π_g to X²Σ⁺ for MgF and D²Σ⁺ to X²Σ⁺ for SrH.

MULTIDIPOLE PLASMA DATA ACQUISITION SYSTEM FOR THE HEWLETT PACKARD 3000 COMPUTER. D. G. Fitzsimons* and C. R. Taylor, Jr. Physics Dept., James Madison Univ., Harrisonburg, Va. 22807.

The preliminary design for interfacing a Langmuir probe and a Hewlett Packard 3000 computer is presented. The probe bias voltage and collected current are sampled simultaneously and converted to either eight or twelve binary bits. These data pairs are stored in a Motorola 6800-based microcomputer as the Langmuir probe bias voltage is swept. After this Langmuir trace is completed, the microcomputer transmits the data over a standard telephone line into a file in the time-sharing HP3000 computer.

A TECHNIQUE INVOLVING CARDINAL FUNCTIONS ON LINEARLY ORDERED TOPOLOGICAL SPACES. Marlene E. Gwand*, Dept. of Mathematics, United States Naval Academy, Annapolis, Md. 21402 and Scott W. Williams*, Dept. of Mathematics, State University of N.Y. at Buffalo, Buffalo, N.Y. 14212.

We show a technique of defining equivalence relations on a linearly ordered topological space (LOTS). Then by examining the resulting quotient spaces, we are able to determine properties of the original space.

Using this technique, we can characterize the Lindelöf degree of LOTS. We also use this technique to determine when a Lindelöf (or paracompact) LOTS will have a Lindelöf (or paracompact) product with any other Lindelöf (or paracompact) space.

RADIO ASTRONOMY: A WINDOW INTO THE ACTIVE NATURE OF GALAXIES P. E. Hardee*, Astronomy Department, University of Virginia, Charlottesville, Virginia 22903.

Before the advent of radio astronomy only a small number of galaxies were known to be active. The activity was manifested by a peculiar overall appearance or by the presence of unusual emission features. Galaxies appeared to be quiescent, slowly evolving, self-gravitating collections of stars and gas. With the development of modern radio astronomy, i.e., single dish telescopes with large surface area and high sensitivity and multiple element radio interferometers with high resolution, the perception of galaxies began to change.

Radio surveys of the sky revealed the existence of powerful radio sources. These radio sources usually had double structure with a galaxy between the two radio lobes. The separation between the lobes was as much as 1000 times the size of the optical galaxy. Radio sources not associated with known galaxies led to the discovery of quasars. Several different types of radio source associated with active galaxies are now known. Compact sources coincident with galactic nuclei and quasars sometimes are variable with timescales of less than a month. The appearance of some radio sources suggests that jets of material can be ejected from the nucleus of a galaxy or quasar. It is thought that these objects can be powered by the infall of material in an accretion disk into a massive black hole at the center of a galaxy or quasar.

ULTRA HIGH RESOLUTION TUNABLE DIODE LASER SPECTROSCOPY OF FREON-12 FROM 1150 CM⁻¹ TO 1172 CM⁻¹. C. N. Harward*, Physics Dept. of Old Dominion Univ., Norfolk, VA 23508, J. M. Hoell*, and C. H. Bair*, Langley Res. Ctr. NASA, Hampton, VA 23665

Ultra high resolution spectra of the Q-branch of Freon-12 (CCl₂F₂) have been obtained using tunable diode laser spectroscopy. Continuous spectra are presented from 1150 cm⁻¹ to 1172 cm⁻¹ with a spectral resolution $\leq .001$ cm⁻¹. Absolute wavelength calibration was obtained using the SO₂ spectra as a standard and a 5 cm Ge etalon for relative calibration between SO₂ lines. The relative accuracy of the Freon-12 line positions was $\leq .0001$ cm⁻¹. The Freon-12 data, obtained at a pressure of 10⁻³ torr, exhibited a rich and highly structured spectra. However, with the exception of two isolated features within the 22 cm⁻¹ studied here, collisional broadening reduces the spectra to a structureless continuum for nitrogen pressures greater than 20 torr. These two features continue to exhibit structure at atmospheric pressure. These results are significant for remote atmospheric measurements of Freon-12. (Aided by NASA grant 1466).

FLOW DIAGNOSTICS IN UF₆. I. ION AND PARTICLE PRODUCTION BY LASER-INDUCED ELECTRICAL BREAKDOWN. II. RAYLEIGH SCATTERING OF LASER LIGHT. P. A. Hodgkinson* and S. S. Fisher, School of Engineering and Applied Science, University of Virginia, Charlottesville, Va. 22901.

Methods are being developed to measure densities and velocities in flowing UF₆ gas. Apparatus has been developed to study the production of ions and particles when a pulsed nitrogen laser is focused in the gas and causes electrical breakdown. Ion production as a function of gas pressure and laser power has been measured, and ion lifetimes have been determined. Only an approximate characterization of particle formation in this process has been obtained. These particles result from photo-dissociation of UF₆ molecules followed by polymerization of non-volatile fragments. These ions and particles are of interest as potential flow tracers. Rayleigh scattering of photons from an Ar-ion laser beam by UF₆ molecules has also been examined. Initial data indicate that this scattering provides a sensitive basis for remote density sensing.

THE COMPUTER AND LEARNING PHYSICS: A STUDENT'S READOUT. S. L. HUTTON* Dept. of Physics, Univ. of Richmond, Va. 23173.

As a junior physics major at a liberal arts school which does not yet use the computer as a pedagogical tool on an appreciable scale, I am essentially self-acquainted with some of its potentials in that context. Initial contact with the machine through games builds confidence, plotting modes are useful as would be more sophisticated graphics for visualizing results of theory, and statistical analyses of laboratory data can be used to extract more than just the "right answer". These roles are limited to the realm beyond the classroom, but computer accessibility in the science center enhances the degree to which they can support and expand traditional course approaches. They may also reduce direct demands upon the professor. Extensive training of the student in a "computer science" oriented curriculum is not essential to his fruitful use of the computer as a learning tool.

DIFFRACTION PATTERN OF NaCl CRYSTAL BY A DENTAL X-RAY MACHINE OF WYTHEVILLE COMMUNITY COLLEGE. D. L. Treat*, Y. P. Hwu. Physics Dept., Wytheville Community College, Wytheville, VA 24382.

In order to study the diffraction effect of a crystal by x-ray, we have been using a dental x-ray machine of the college. It proved to be successful. We think it is money-saving. We wish to thank Mrs. Joanne D. Mitchell for giving us permission to use the machine.

FERMAT PRINCIPLE FOR AN ELLIPTICAL SURFACE.

K. Naderi*, Y. P. Hwu. Physics Dept., Wytheville Community College, Wytheville, VA 24382.

Laser light reflected from an elliptical surface has been studied theoretically and experimentally. The optical path could be maximum, minimum, and constant.

MATHEMATICAL PATTERN OF THE BEAT OF TWO GRATINGS.

D. Hwu*, Y. P. Hwu. Physics Dept., Wytheville Community College, Wytheville, VA 24382.

Mathematical pattern of the "beat" of two given gratings has been studied and also worked experimentally:

STANDING WAVE BY THE SPRING ON A CENTRIFUGAL MACHINE. N. Shaver*, Y. P. Hwu. Physics Dept., Wytheville Community College, Wytheville, VA 24382

When a centrifugal machine rotates up to a certain speed, a standing wave pattern has been observed and studied.

THIRD DERIVATIVE AND CONCAVITY. Will Patterson*, L. T. Liddle, Y. P. Hwu. Physics Dept., Wytheville Community College, Wytheville, VA 24382.

The relation between concavity and third derivative of a curve has been studied and an example will be given.

HAND-ON HOLOGRAPHY SHOW. P. Bowman*, Y. P. Hwu. Physics Dept., Wytheville Community College, Wytheville, VA 24382.

A hand-on holography show has been given to some high school students. The result proved to be encouraging and interesting.

A FEW DEMONSTRATIONS IN GENERAL PHYSICS.

A. Aghajari*, T. Hortor*, S. Nichols*, Y. P. Hwu. Physics Dept., Wytheville Community College, Wytheville, VA 24382.

Twin Newton's Ring; Diffraction Pattern of A Blood Cell and others will be demonstrated.

EXPERIMENTAL ELECTRON ENERGY DISTRIBUTIONS IN MULTIDIPOLE ARGON AND HYDROGEN PLASMAS. M. A. Kessel* and C. R. Taylor. Physics Dept., James Madison Univ., Harrisonburg, VA. 22807.

Evaluations of the experimental electron energy distributions in multidipole argon and hydrogen plasmas at high and low neutral pressures are presented. Results are compared with Maxwellian distributions of the same average energy and with plasma parameters obtained by the usual Langmuir probe characteristic analysis. Within experimental error the distributions are found to be Maxwellian except at high neutral pressures of 5×10^{-3} Torr, where small deviations from Maxwellian behavior are observed.

TRANSIENT BEHAVIOR IN GAS BREAKDOWN. J. Littell* Old Dominion University, Norfolk, VA 23508, and J. W. Wilson, NASA Langley Research Center, Hampton, VA 23665

There is considerable interest in the transient breakdown of gases in connection with the development of gas lasers. This is especially true in the development of nuclear-pumped gas lasers for which transient electrical discharge pumping is used to "stimulate" the nuclear-induced plasma. In order to interpret such simulated results, the properties of the transient electrical discharge generated plasma must be known.

Results from the study of transient breakdown in helium gas and gas mixtures using a time-dependent Townsend model will be presented. The role of background ionizing radiation will be discussed along with space charge effects. The breakdown of helium gas is strongly dependent on the impurity level of Penning type gases for which Penning ionization and photoelectric ionization are possible. The rapid breakdown in long discharge tubes is achieved by Penning and photo-ionization. Numerical examples will be given.

THE USE OF FUNCTION SPACES TO STUDY TOPOLOGICAL PROPERTIES. R. A. McCoy*, Dept. of Math., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A technique is examined in the use of spaces of continuous functions for the study of topological properties of spaces. The general kind of problem illustrated here is that of finding topological properties P and Q such that a space has property P if and only if C(X) has property Q, where C(X) is the space of continuous real-valued functions on X under some given topology - such as the compact-open topology.

THE THREE THOUSAND FACES OF A HEXAGON. T. Bruce McLean*, Department of Mathematics and Computer Science, James Madison University, Harrisonburg, Virginia 22807

While attending graduate school at Princeton University in 1959, J. A. R. Stone created a Mobius Band with three half twists into a flexible hexagon. Using a technique called a pinch flex, the paper model will produce three different faces. By doubling the length of the band, Stone created the first six faced flexagon and Bryant Tuckerman provided the traverse. Richard Feynman and John Tukey joined Stone and Tuckerman on the first flexagon committee and Louis Tuckerman added to the later work. In 1957, C. O. Oakley and R. J. Wisner finished the work with some assistance by Henry Gould. Martin Gardner supplied the history in a 1956 Scientific American article.

In this paper, a second way to flex the six faced flexagon of Stone is presented. The Oakley and Wisner paper is used to count the three thousand four hundred and twenty faces that are now possible and provide the traverse for these new faces.

Valuable insight to the final solution was provided by high school students Alan Moluf and Robert Verrey in 1965. In their honor, we refer to this new technique as a V-flex.

ELECTRICAL POTENTIALS AND FIELD COMPONENTS DUE TO A CHARGED SMOKE PLUME. Alex F. Ferlian* and G. E. Copeland, Physics Dept., Old Dominion University, Norfolk, VA 23508. Electrical potentials at over 8.0×10^{14} grid points have been obtained from an iterated numerical solution to Poisson's equation $\nabla^2 \phi = -\rho(\mathbf{xyz})/\epsilon_0$. The source term $\rho(\mathbf{xyz})$ is obtained from the Gaussian like pollutant concentrations that result from solutions to the Pasquill-Gifford diffusion problem. Solutions for $\phi(\mathbf{xyz})$ are obtained for several meteorological stability classes (conditions), pollutant source emissions, and all eddy diffusion coefficients σ_y and σ_z . Cross wind and vertical electric intensity components (E_y and E_z) are obtained via numerical differentiation. An attempt is made to relate the functional forms of $E_z = E_z(\mathbf{yz})$ to the known behavior of the σ_y and σ_z so that remote sensing of atmospheric fields may be used to distinguish diffusion characteristics of charged smoke plumes.

PROSPECTS FOR TOKAMAK HYBRID REACTORS. W. G. Pettus, Babcock & Wilcox Co., Lynchburg Research Center, Lynchburg, Va. 24505.

In the past few years there has been renewed interest in fusion-fission hybrid reactors for central station power production, fissile fuel enrichment, and other applications. The various proposed reactor concepts are reviewed briefly here and the prospects for tokamak hybrids in particular are discussed.

In these systems the plasma serves as a high energy neutron source which drives a subcritical blanket of fissile/fertile material. Several different fusion reactions are considered including D-T, D-D, and catalyzed D-D. A few of the most promising blanket concepts are described and the potential contribution of these systems to the national energy program is indicated. Safety, environmental, and nonproliferation concerns are also discussed.

AN APPROXIMATION TECHNIQUE IN UNIFORM SPACES. M. D. Rice, Dept. of Mathematics, George Mason University, Fairfax, VA 22030.

The basic technique mentioned in the title is the approximation of uniformly continuous mappings by Lipschitz mappings. In particular, one can establish that each bounded real-valued uniformly continuous mapping on a metric space may be uniformly approximated by a Lipschitz mapping defined on any containing metric space. The Katětov extension theorem can be immediately derived as a corollary. The preceding result may be used to establish that each Hilbert space valued uniformly continuous mapping defined on a convex set K in a Banach space can be uniformly approximated by a Lipschitz mapping on K . From this result, one deduces that for every uniformly continuous mapping $f: K \rightarrow K$ and every $\epsilon > 0$ (where K is a closed convex set in a Hilbert space), there exists x in K and $\lambda > 0$ such that $|f(x) - \lambda x| < \epsilon$. The preceding results will also be related to the characterization of the subsets of the real line which allow the unrestricted extension of real-valued uniformly continuous mappings and to the discussion of the analogous property in the plane.

A DETERMINANTAL PROPERTY OF AUXILIARY MATRICES. Rana P. Singh, Department of Mathematics, Virginia State College, Petersburg, Virginia 23803.

Let $I^{(k,m)}$ denotes an auxiliary matrix obtained by rearranging the columns of $I_{m \times m}$ by taking every k -th column starting with the first, then every k -th column starting with the second, etc., where k divides m . Then

Theorem 1. $\det I^{(k,m)} = +1$ if $\frac{m(m-k)(k-1)}{4k}$ is even
 $= -1$ if $\frac{m(m-k)(k-1)}{4k}$ is odd.

The auxiliary matrices preserve the dimension and the number of 1's and 0's of the basic identity matrix.

EARLY MAYAN ASTRONOMY. Charles D. Smith and Paul H. Knappenberger, Jr. Science Museum of Virginia, 2500 W. Broad Street, Richmond, VA 23220.

The Mayans were one of the most advanced civilizations in Pre-Columbian America. They developed a knowledge of astronomy which enabled them to make accurate predictions of the motions and positions of celestial bodies. This knowledge permeated Mayan culture, influencing religious beliefs, agriculture, architecture, the calendar, and many other aspects of the civilization. This paper will review the role and degree of development of Mayan astronomy. Examples from major archaeological sites such as Uxmal, Palenque, and Chichen Itza will be shown.

TECHNIQUES FOR CONSTRUCTING VARIOUS REFINEMENTS OF POINT FINITE COVERS. J.C. Smith*, Dept. of Mathematics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Several techniques are discussed for obtaining various types of refinements of point finite and generalized point finite open covers of topological spaces. Characterizations of various topological properties are then obtained as applications of these results.

MAGNETIC MONOPOLES - WHERE THEY ARE NOT AND

W. Peter Trower, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

The symbiotic relationship between electricity and magnetism lacks the full measure of equality in that an isolated magnetic charge has never been seen while electric counterparts abound in abundance. Theoretical desires for magnetic monopoles, which are motivated by world views ranging from purely technical to Olympian, are numerous and growing. In spite of this demand the diligent and inventive experimentalist has yet to discover any phenomenon which requires for its unequivocal elucidation the existence of this putative particle. Here we review the history, enumerate the motivations, examine the evidence, and speculate on the future prospects for this Unicorn of particle physics.

LETTERS FROM THE R.L. MOORE COLLECTION. Lucille Whyburn, Department of Mathematics, University of Virginia, Charlottesville, Va. 22903

R.L. Moore was the founder of Foin-set Topology in the United States. He left his papers to the University of Texas where he carried on an active graduate program even after the usual retirement age. The University has assembled these papers in the MOORE COLLECTION of their Humanities Research Center where they are available to scholars. This paper presents a sampling of the many interesting letters in the R.L. MOORE COLLECTION.

MODELING OF A SOLAR-PUMPED IODINE LASER. J. W. Wilson, NASA Langley Research Ctr., Hampton, VA 23665; J. H. Lee,* Vanderbilt University, Nashville, TN 37235

The direct conversion in space of solar radiation into laser radiation for power transmission to Earth, satellites, or deep space probes shows promise as a reasonably simple technology and may have cost advantage in deployment and greater reliability compared to other methods of space power generation. The main candidates for solar pumping are the gas dynamic, photochemical, and direct photoexcited lasers. We consider here the photochemical reaction of alkyl iodides which predominantly excites the $I(2P_{1/2})$ state which lases at 1.315 μ m. The iodine ground state is eventually lost to reconstituting the gas or in the formation of molecular iodine. The rates at which the gas is required to be recycled through the laser system are modest. The side exposure at 100 fold solar concentration of a 100 m long tube with a 3 m by 30 cm cross section is estimated to provide up to 20 kW of continuous laser output. Scaling laws and optimum operating conditions of this system will be discussed.

*This work was supported in part by NASA grant, NSG-1235.

ANALYSIS OF SPECTROSCOPIC PLATES. John H. Wise, Dept. of Chemistry, Washington and Lee University, Lexington, Virginia 24450.

The Argonne 9.15 m Paschen-Runge spectrograph produces an abundance of high resolution spectroscopic plates which require analysis. A Gaertner comparator has been interfaced with the SIGMA V computer in the Chemistry Division, making use of a linear encoder and a high speed DVM. A set of computer programs has been developed for the analysis, and these may be subdivided into several groups: assembler language programs to handle data acquisition (originally devised by John Hines at Argonne), and FORTRAN programs for comparator analysis, for data treatment, for graphics display, and for disc file output. The most significant program is for peak finding. The procedure involves a search for a string of negative second derivatives, with the peak chosen at the center of the string. Program results are: peak position, peak width, peak shape code, and a measure of peak intensity. Operation of the comparator, the interaction of the programs and some typical applications will be described.

(Work done at Argonne National Laboratory, Argonne, Illinois.)

Biology

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

SEROLOGIC AND ELECTROPHORETIC ANALYSES OF VARIOUS ORGAN EXTRACTS OF THE AMERICAN DOG TICK, DERMACENTOR VARIABILIS (SAY). S. B. Ackerman, Mary C. Floyd*, and T. W. McGill*. Department of Biological Sciences. Old Dominion Univ., Norfolk, VA 23508.

Soluble extracts of individually excised ovaries, salivary glands, midguts, and foveal glands, and an extract of adult ticks were prepared from the American Dog Tick *Dermacentor variabilis* (Say). Protein compositions of these extracts were analyzed by 7% polyacrylamide gel (PAGE) and 3.5%, 4.75%, 7%, and 12% gradient polyacrylamide gel (G-PAGE) electrophoresis. Antiserum to whole tick extracts were generated in a rabbit and used to compare antigenic compositions of these organs using immunodiffusion (ID) and immunoelectrophoresis (IEP). A list of the extracts and total number of protein bands delineated by PAGE (and G-PAGE when performed) includes: whole tick, 9(20); salivary glands, 12(12); midguts, 4(6); ovary, 11; and foveal glands, (4). Electrophoretic mobility patterns of these extracts were also compared to erythrocyte extracts of several species of hosts and solubilized tick fecal material. Serological analyses indicated that common and organ-specific antigens were present in each of the organ extracts, but no anti-tick antibodies reacted against hosts' erythrocyte preparations. Results of this study will be compared to investigations performed concurrently into the efficacy of some of these extracts as anti-tick vaccine antigens.

THE EFFECT OF STREAM SIZE ON POTAMOPLANKTON COMMUNITIES, Michael L. Bass, Mary Washington College, and James T. Maughan*, Metcalf and Eddy

Basic physical and chemical parameters and plankton samples were taken in riffle and pool areas on Sinking Creek at Newport, Virginia in Giles County and above and below Claytor Lake on the New River. There was no significant difference in plankton population density between the riffle and pool at any site. The plankton population density was significantly higher below Claytor Lake than above and higher above Claytor Lake than in Sinking Creek. The Wilhm and Dorris diversity index, d , for the plankton population was higher in Sinking Creek than either station in the New River. The d value for the riffle areas above and below Claytor Lake were the same. The d value for the pool areas above and below Claytor Lake were the same and lower than the d values for the riffle areas at these stations.

THE OCCURRENCE OF AQUATIC INSECTS IN BIG CEDAR CREEK, RUSSELL COUNTY, VIRGINIA, Michael L. Bass and Robert H. Strickler, Department of Biology, Mary Washington College
The purpose of this study was to describe the macrobenthic fauna of Big Cedar Creek in the area being used as a trout fishery by the Big Cedar Sportsman's Association. Emphasis was put on the aquatic insect community because it is an important source of food for trout and an excellent indicator of stream quality. Field sampling was quantitative, using a Surber type sampler and qualitative, using a D-frame kick net sampler. Forty-four different aquatic insect species representing seven insect orders (Coleoptera, Diptera, Ephemeroptera, Megaloptera, Odonata, Plecoptera, Trichoptera) and five other types of macroinvertebrates were found. The substrate character, streamside cover and water quality parameters along with the macrobenthos indicate that Big Cedar Creek should be an excellent trout growth stream. Monitoring of stream quality is continuing.

NOTES ON NAEGLERIA SPP. AND THE SOILS FROM WHICH THEY ARE CULTURED. Barbara L. Berrent and William H. Yongue, Jr., Department of Biology, V.P.I.&S.U., Blacksburg, VA. 24061

Deaths due to primary amebic meningoencephalitis have been reported in the Richmond area since 1951. The cause of this fatal disease has been recognized as a species of *Naegleria*, more specifically *N. fowleri*. At Virginia Tech, experiments are being conducted on soil samples obtained from seven lakes in the vicinity of Richmond. Our major concern was the numbers of thermophilic (46 C) amoebae that may be found in soil samples, presumably in encysted form. Primary cultures were made from each sample, grown for 48 hours, then serially diluted three times and used to inoculate corneal agar petri dishes. Counts were made following a three day incubation period (at 46 C). The results range from >300 amoebae per field (40x) in Salisbury Lake to <10 per field in Lake Anna Cooling Lagoon. Also noted in Overhill Lake and Fall Creek was variation in the size of amoebae. The cysts and active amoebae in the seven soils ranged from 7-10 μ m; however, in the two lakes, some active amoebae were two and three times larger than the average size. An explanation for this occurrence might be the co-existence of two species. Pathogenicity was not studied in this project. These results support the suggestion that several types of thermophilic amoebae may be characteristic of soils. (Supported by V.P.I. & S.U. Small Projects Grant Program and The Center for Environmental Studies)

EUGLENA GRACILIS: TEMPERATURE AND LD 50. W. Burton Blackburn, William H. Yongue, Jr., and John Cairns, Jr. Dept. of Biology, V.P.I. & S.U., Blacksburg, VA 24061

Euglena gracilis was cultured in soil extract medium and subjected to thermal shock in intervals of 2° from an ambient temperature of 24C to 44C. Temperature shock at approximately 31C was found to 50% of the individuals observed and 100% of the individuals were dead at temperatures of 42C or greater. The degree of morphological changes seemed to be proportional to the degree of thermal shock. *Euglena gracilis* cultured in pond water was subjected to temperature shock at selected temperatures and was found to be more resistant to thermal shock than those cultured in soil extract. This tends to suggest that nutrient level may be a factor in sensitivity to thermal shock. This work is being continued. (Supported by V.P.I. & S.U. Water Resources Research Center and the Center for Environmental Studies)

OCCURRENCE OF CYTODODIA (=TODDIA:PROTOZOA:SPOROZOA) IN NERODIA (=NATRIX) SIPEDON (NORTHERN WATER SNAKE) FROM AN AREA IN SOUTHWESTERN VIRGINIA. Katherine A. Booker and William H. Yongue, Jr. Dept. of Biology, V.P.I. & S.U. Blacksburg, VA 24061

Cytododia is an intraerythrocytic parasite of cold blooded vertebrates. This infection is observed under oil immersion to be a basophilic staining body accompanied by a crystalline mass. This mass varies in shape from host to host.

During the summer of 1978 thirty-six *Nerodia* were collected from a small area of southwestern Virginia. Of the thirty-six *Nerodia* sampled for Cytododia, two were found to be naturally infected.

This is the first record of Cytododia in Virginia.

Previously, Cytododia had only been reported from Michigan and Louisiana. The former occurred in *Nerodia sipedon* and the latter in *Akistrodon piscivorus leucostoma* (the western cottonmouth or water moccasin). A description of the Virginia habitat is given.

A COMPARATIVE STUDY OF CELLULAR ADHESIVENESS IN CULTURED HUMAN NORMAL, CYSTIC FIBROSIS, AND HUNTINGTON'S DISEASE FIBROBLASTS. G.L. Bumgardner, D. Fisher, and L.L. Wiseman. Biology Dept., Col. of William and Mary, Williamsburg, VA 23185

The investigation of cell surface molecules involved in vertebrate cellular adhesiveness might be facilitated by finding "adhesive mutants." We chose to study two mutant fibroblast lines, cystic fibrosis and Huntington's Disease, which, from the literature, we suspected might show adhesive differences when compared to normal cells (all cells from The Human Genetic Mutant Cell Repository in Camden, NJ). Cystic fibrosis cells exhibited rates of rotation-mediated *in vitro* cell aggregation and rates of sticking to plastic similar to normal. Huntington's cells stuck to plastic as did normal and did not sort out from normal cells in mixed heterotypic aggregates. However, Huntington's cells appeared to aggregate somewhat faster than normal cells, forming larger cellular aggregations after ten to twelve hours of rotation culture. We are currently studying the effect of glucosamine on Huntington's Disease cellular aggregation (cell adhesion) because it has been reported that this molecule may affect the morphology and ability of Huntington's cells to stick to plastic in minimal medium.

INTRANASAL IMMUNIZATION OF MICE AGAINST NAEGLERIA FOWLERI. L.E. Bush, A.J. Seidenberg and D.T. John. Depts. Biol. and Microbiol., Va. Commonwealth Univ., Richmond, VA 23298.

There is little information on the alteration of the outcome of *Naegleria fowleri* infections by immunotherapy. Accordingly, we have evaluated the capability of various intranasal (I.N.) immunization procedures to evoke increased resistance to challenge with lethal doses of live *N. fowleri*. Male DUB/ICR mice weighing 13-18g were used in all experiments. Mice were immunized and challenged I.N. and deaths were recorded for 21 days after challenge and percent protection calculated. Mouse mortality from various *N. fowleri* strains ranged from 0 to 100%. Strains of high-, medium- and low-virulence (WM, LEE & CJ, respectively) were used to immunize three groups of mice. WM produced the best protection (77%); however, 67% of the mice died before challenge. CJ afforded no protection, and LEE produced 72% protection with only 17% of the mice dying before challenge. LEE strain was used to immunize mice 1, 2, 3 or 4 times with doses ranging from 10^2 to 10^5 amebae/mouse. Mice that had been immunized 3 times with 10^3 amebae/mouse exhibited the best protection (56%) against lethal challenge. Again, LEE was used to immunize mice that were challenged either 1 or 2 weeks after immunization. Mice challenged 2 weeks after immunization showed consistently greater protection. N. gruberi, a nonpathogen, was used to immunize mice either 1, 2, 3 or 4 times. Mice that had been immunized 3 times exhibited the best protection (86%).

POPULATION DYNAMICS AND CONTROL STRATEGIES FOR FREE-RANGING BURROS: A MODELLING APPROACH. Mark T. Butte*, Alan R. Tipton* and Patrick F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061

A literature search was used to generate data on reproductive success and longevity of feral burros (*Equus asinus*). Using a modified Leslie matrix seven possible population age structures were generated. Of these, the simulation using 0.57 foals/female/year and a standard mortality produced results comparable to published material on domestic burro reproduction and observations on feral animals. From a stable age structure with 1413 females, five control methods were evaluated: 1) reduction of natality by exogenous drugs, 2) % cropping of adults, 3) % cropping of young, 4) predetermined cropping of all ages, and 5) % cropping of all ages. A 20% cropping of immature burros for five years reduced the population from 1413 to 1130, a 20% decrease. Although other methods produced greater reductions, this method is considered the most useful approach for managing burros for the following reasons: population structure is not radically altered; a significant reduction of animals is imposed; young animals are more vulnerable; the control could be carried out with limited funds and knowledge of the population to be controlled.

EFFECT OF MATERNAL AUTOIMMUNITY ON REPRODUCTIVE SUCCESS AND THE INCIDENCE OF ANEUPLOID OFFSPRING IN MICE. Carolyn M. Conway and Arthur F. Conway, Depts. of Biology and Anatomy, Va. Commonwealth Univ., Richmond, VA 23284

The effect of specific and non-specific immune stimulation on reproductive success (e.g., litter size, neonatal survival) and the incidence of aneuploid and mosaic offspring was studied in CD-1 mice. Autoimmune thyroiditis was induced in female mice by subcutaneous injections of thyroid homogenate-Freund's adjuvant emulsions. Non-specific immune stimulation was achieved by subcutaneous injections of saline-Freund's adjuvant emulsions. Liver cells from 17 day fetuses were used for chromosome analysis. Aneuploid fetuses were found only in those females in which autoimmune thyroiditis was induced. Mosaic fetuses were found among the offspring of all immune stimulated females. These results suggest a correlation between maternal autoimmune disease and chromosomal nondisjunction during either the meiotic divisions of oogenesis and/or the mitotic divisions of embryogenesis. Neonates born to some females in which autoimmune thyroiditis was induced showed significantly reduced survival. In addition some of these neonates exhibited the characteristic symptoms of runt disease indicating that immune competent cells crossed the placenta and affected postnatal development of the offspring. (Supported by the Grants-In-Aid Program for Faculty of Va. Commonwealth Univ.)

INFLUENCE OF MAGNESIUM ON CADMIUM TOXICITY EFFECTS ON CELL DIVISION AND CALCIFICATION IN THE COCCOLITHOPHORID ALGA, *CRIOCOSPHAERA CARTERAE*. K. E. CORUM* and E. F. STILLWELL. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Cadmium (Cd) added to normal media and to magnesium (Mg)-deficient media produced inhibitory effects on cell division and cell calcification in the coccolithophorid alga, *Criocosphæra carterae*. Compared with controls in normal media (25 mM Mg), cell growth decreased progressively with added Cd concentrations (1.0-20 µM). In Mg-deficient media (6 mM and 0.08 mM Mg) the inhibitory effects were more pronounced with complete arrest of cell division at 20 µM Cd. The greatest Cd inhibition occurred in media with the lowest Mg concentration (0.08 mM). Cadmium (1.0-20 µM) also decreased recalcification (coccolith formation) in cells previously decalcified with O_2 with complete inhibition at 40 µM Cd. Inhibition of recalcification in various Cd concentrations (1.0-20 µM) was more pronounced in low-Mg media (0.08 mM) compared with normal media (25 mM Mg). Partial or complete reversal of the inhibitory effects of Cd and low Mg media on cell division and calcification occurred following a wash and resuspension of the cells in normal control media (25 mM Mg).

THE ECOLOGY OF CUTEREBRA PARASITISM IN *PEROMYSCUS LEUCOPUS*. Jack A. Cranford. VA Polytechnic Inst. and State Univ. Bio. Dept., Blacksburg, VA 24061

The host-parasite relationship between *Cuterebra fontinella* and *Peromyscus leucopus* will be discussed as the result of intensive lab. rearing of both the parasite and its host. The mean generation time of *C. fontinella* is 76.8 ± 1.4 days under conditions of 20°C and LD 16:8. The adult flies are sexually dimorphic which results in different times in the larval as well as the pupal stages. *P. leucopus* maintains normal weight balance while infected but increased food consumption occurs reaching its peak just prior to the parasites emergence from the host. Among 10 other species tested for their susceptibility to parasitism *Tamias striatus*, *Glaucomys volans*, *Clethrionomys gapperi*, and *Neotomus albigularis* show no reaction to the parasite and no successful infections were noted. The results in six other species vary from partial infection to total infection resulting in death of the host. In the normal host *P. leucopus* some form of partial immunity results as the successful infection rate drops from 74% to 45% on the second cycle and to 37% on the third cycle.

Other projects currently under way within my laboratory will be discussed. 1. *Peromyscus leucopus*, *Peromyscus maniculatus* and *Zapus hudsonius*, *Neotomus albigularis* competitive interactions. 2. Ecology of *Synaptomys cooperi* in VA. 3. Maternal and Paternal contributions to offspring rearing in *Microtus pennsylvanicus*. 4. *Zapus* hibernation ecology.

OSMOTIC FRAGILITY OF RED BLOOD CELLS OF MARINE INVERTEBRATES. Robert Penamache*, Dept. of Biology, Col. of William and Mary, Williamsburg, VA 23165

The osmotic fragility of a red blood cell population is described by the percentage of cells that lyse when placed in increasingly hypotonic solutions. While osmotic fragility has been studied extensively in mammals, little information exists for red cells of invertebrates. Unlike vertebrate blood, the fluids that bathe invertebrate red cells may vary greatly in osmotic concentration, temperature and pH. The osmotic fragility of red cells of five invertebrate species, representing four phyla, were investigated, and the results compared with previous findings on mammalian red cells.

WOOD DUCK NESTING AND BROOD UTILIZATION OF AGRICULTURAL FIELD WETLANDS IN A FLOODPLAIN. R. T. Di Giulio*, School of Forestry and Wildlife, Louisiana State Univ., Baton Rouge, La. 70803

Artificial Wood Duck (*Aix sponsa*) nesting boxes were placed in 5 wetlands in a Louisiana floodplain which were surrounded by agricultural fields and contained no natural nesting cavities. Nesting use of the boxes and duck brood usage of these wetlands and 4 similar wetlands containing neither natural nor artificial cavities were examined.

In 1976, 5 successful Wood Duck nests were found in the boxes. In 1977, 11 successful Wood Duck nests and 4 successful Hooded Merganser (*Lophodytes cucullatus*) nests were observed. No ducklings were observed in agricultural field wetlands beyond the day on which they exited nest boxes. Two Wood Duck hens, presumably leading broods, were followed by radio-tracking. Both hens apparently led their broods to larger, more isolated wetlands which contained more aquatic vegetation. An absence of herbaceous vegetation was concluded to be an important factor contributing to the lack of brood usage of the agricultural field wetlands. (Aided by Louisiana Department of Wildlife and Fisheries, Louisiana Agricultural Experiment Station, and the National Skeet-shooting Association)

BIOGEOGRAPHY OF MAMMALS ON THE VIRGINIA BARRIER ISLANDS. Raymond D. Dueser and John H. Porter*, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903

Small mammal populations were sampled on 9 Virginia barrier islands. The number of species ranges from 0 on a small, sparsely-vegetated island (Little Cobb) to 5 on a large, forested island (Parramore). Species diversity (= richness) increases directly with island area, elevation and habitat complexity. Each species occupies an optimal habitat in which it is particularly abundant. Habitat expansion (the occupation of multiple plant associations) is associated with high population density in optimal habitat. There is circumstantial evidence that competition also affects species distributions. The small mammal communities on these islands represent equilibrium conditions, with low rates of colonization and high rates of extinction interacting to produce a steep species-area curve. Intensive studies of 7 small mammal species on Assateague Island, just north of the Virginia islands, confirm that habitat selection and competition both influence species distributions on an island. Although competition is pervasive among these species, only a single species was limited in distribution primarily by competition.

VOLUME REGULATION IN AN ESTUARINE ANNELID. J.A. Dykens*. College of William and Mary, Williamsburg, Va. 23185

Upon exposure to dilute sea water, the annelid *Nereis succinea* swells a predictable amount. With continued exposure, the animal adjusts its volume towards the initial size by active metabolic processes that require oxygen and are retarded by cold. Ammonia excretion increases prior to and remains elevated during regulation implying an increased energy demand for this process. Ouabain inhibits this excretion, but has no effect on volume readjustment. Manipulation of the ionic composition of the media indicates that volume regulation is not heavily dependent on passive fluxes of K^+ , Na^+ or Cl^- . Volume regulation is not affected by either Amiloride or Diamox. Volume readjustment does not occur if either Ca^{++} or Mg^{++} are absent.

A NEW DEVELOPMENT IN MEASURING INTRAFOLLICULAR PRESSURE IN RABBIT OVARIES PRIOR TO OVULATION. K. F. Flagg¹ and R. J. Swanson, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Measurement of intrafollicular pressure in rabbit ovaries requires glass microneedles with bores varying in diameter from 15-25 μ m for injection to 20-40 μ m for pressure recording. A micropipette grinder is used to produce sharp, beveled, and smooth needles.

Surgery is performed on female rabbits two to four hours postcoitus. With the ovary exposed, selected Graafian follicles are injected with normal rabbit serum (NRS) or physiological saline (PS), while simultaneously recording pressure. Pressure thus measured shows an immediate intrafollicular rise, which is sustained for several minutes in the case of NRS and for less than a minute with PS. We feel that the time difference is due to differing diffusion characteristics of the two fluids.

SOME REACTIONS OF WHITE-TAILED DEER TO XYLAZINE HYDROCHLORIDE. David F. Gibson¹, Anne Oelschlaeger², Patrick F. Scanlon, and Roy L. Kirkpatrick, Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Xylazine hydrochloride (Rompun) was used in 47 attempts to immobilize adult female white-tailed deer (*Odocoileus virginianus*). Doses were given at the rate of 2.2 mg/kg body weight (B.W.) or on a metabolic body weight basis (BW^{0.75}). Administration was either by means of a blowpipe syringe or manual syringe following manual restraint. The deer were either injected during manual restraint or were injected with the blowpipe syringe after release. Data were recorded on induction times, rectal temperatures and respiration rates, at collapse and 15, 30, and 90 minutes after collapse. Mean induction times (S.D.) for the different administration methods ranged from 6.3 (4.7) to 11.7 (7.3) minutes but did not differ significantly among treatment groups. Respiration rates of immobilized deer were erratic with periods of apnea and hyperpnea. Rectal temperatures declined significantly over time during immobilization. Recovery from immobilization was usually 2-3 hours after injection.

INFLUENCE OF FOOD RESTRICTION AND CADMIUM INGESTION ON BODY GROWTH AND ORGAN WEIGHTS OF MALLARD DUCKLINGS. Daniel C. Gray¹, Patrick F. Scanlon, and Roy L. Kirkpatrick. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A total of 96 mallard (*Anas platyrhynchos*) were assigned to either of 2 feeding levels (ad libitum or 80% ad libitum) and one of 4 Cadmium levels (0, 10, 50, or 250 μ g/g Cadmium in the diet). Diets of restricted ducklings were adjusted every second day based on ingestion rates of the ad libitum fed ducklings. All ducklings were killed at 28 days and the following data recorded; sex, body weight, weights of brain, liver, and kidneys, packed cell volume (PCV) of blood, and calcium levels of bones were determined later by atomic absorption spectrophotometry. Data were analyzed by Analysis of Variance. Nutrition level had significant effects on bodyweight ($P<0.0001$), brain weight ($P<0.0001$), liver weight ($P<0.0001$), and kidney weight ($P<0.0001$). Cadmium level significantly affected body weight ($P<0.0001$), brain weight ($P<0.001$), liver weight ($P<0.005$), PCV ($P<0.0001$), and bone calcium levels ($P<0.01$). There were significant interactions of cadmium x nutrition ($P<0.005$) on PCV and of nutrition x sex ($P<0.05$) or bone calcium levels.

INFLUENCE OF LEVEL OF CADMIUM INGESTION AND DIETARY RESTRICTION ON RETENTION OF CADMIUM IN TISSUES OF MALLARD DUCKLINGS. Daniel C. Gray¹, Patrick F. Scanlon, and Roy L. Kirkpatrick. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Cadmium levels in brains, livers, kidneys, bones, and feathers of mallard ducklings (*Anas platyrhynchos*) were determined by atomic absorption spectrophotometry following death at 28 days. The ducklings (N=96) were randomly assigned on Day 1 of life to one of two nutrition levels (ad libitum or 80% ad libitum) and to one of 4 cadmium levels (0, 10, 50, or 250 μ g/g of feed). Analyses of variance were used to analyze data. Significant ($P<0.0001$) effects of cadmium level were found on cadmium levels of all tissues (brain, liver, kidney, bone, and feathers). Nutrition level significantly ($P<0.05$) influenced brain cadmium levels. There were significant interaction effects as follows: liver cadmium, cadmium level x nutrition level ($P<0.05$); kidney cadmium, cadmium level x nutrition ($P<0.01$); bone cadmium, nutrition x sex ($P<0.01$) and cadmium level x nutrition level x sex ($P<0.005$); feather cadmium, cadmium level x nutrition level ($P<0.005$), and cadmium level x nutrition level x sex ($P<0.05$).

INFLUENCE OF CADMIUM INGESTION AND FOOD RESTRICTION ON SELECTED BEHAVIORS OF MALLARD DUCKLINGS. Daniel C. Gray¹, Patrick F. Scanlon, and Roy L. Kirkpatrick. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A total of 96 mallard (*Anas platyrhynchos*) ducklings were randomly assigned to one of 2 nutrition levels (ad libitum and 80% ad libitum) and to one of 4 levels of cadmium (0, 10, 50, and 250 μ g/g feed) on the first day after hatching. Avoidance behavior was tested on day 5 and open field behavior was tested on day 10. Avoidance behavior was tested in an apparatus which provided a frightening stimulus and automatically recorded the distance run by ducklings at 2 seconds after provision of the stimulus. Open field behavior was measured in a 60x60x30 cm box fitted with 4 pairs of photoelectric light sources and was recorded as the number of times light beams was interrupted in a 3 minute interval. Analysis of Variance tests indicated that neither nutritional level nor cadmium level significantly influenced avoidance behavior. Nutrition level significantly ($P<0.05$) influenced open field behavior though cadmium level did not.

THE DISTRIBUTION OF THE SOUTHEASTERN SHREW, *Sorex longirostris*, IN VIRGINIA. Carol S. Jones¹ and John F. Pageis². Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284

Records were obtained of captures of the southeastern shrew, *Sorex longirostris longirostris*, from 29 localities in Virginia. Most of the sites are in the Piedmont and a few in the Coastal Plain. We were able to locate only three specimens from the Ridge and Valley Province. Most of the southeastern shrews taken in the State were from elevations approximating 500 ft, but one site in Page County was 1200 ft. Ecological data indicate that this shrew is largely restricted to habitats that may be variously described as old field, edge, or disturbed areas in forests. Ponds or streams are usually nearby, and the plant most often noted is Japanese honeysuckle.

A second subspecies, the Dismal Swamp shrew, *S. l. fisheri*, was not considered in the present study.

TESTOSTERONE CONCENTRATIONS IN CHINCHILLAS. J. Thomas Jones*, Patrick F. Scanlon, Wanda B. Morehead* and Francis C. Gwadauskas. Depts. of Fisheries and Wildlife Sciences, and Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Testosterone (T) concentrations were determined by radioimmunoassay (RIA) in blood plasma of post pubertal male chinchillas (*Chinchilla laniger*). A total of 22 males were used in the experiment. Each was individually housed in cages maintained at 22 C in a 14:10 light dark cycle. Blood samples were taken during each hour of the day. Each male was sampled 3 or 4 times. Males were assigned bleeding times (i.e. hours of day) and two weeks were allowed to elapse between successive bleedings of individuals. Bleedings were by heart puncture following anesthetization with methoxyfluane. Mean T concentrations for all 85 samples assayed were 2.75 ng/ml (1.96 S.D.). The range of T values was 0.17 ng/ml to 9.25 ng/ml. T values tended to be minimal for samples taken between 1200 and 1300 hrs.

LEAD LEVELS IN MOURNING DOVES COLLECTED FROM MID-ATLANTIC STATES IN 1977. R. J. Kendall and P. F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Lead concentrations ($\mu\text{g/g d.w.}$) were determined by atomic absorption spectrophotometry in bone tissues of 236 mourning doves (*Streptopelia risoria*) collected by hunters in 8 counties of 4 Middle Atlantic States (MD, VA, NC, and SC) as part of a monitoring project for lead contamination. Mean lead levels, [S.D.], and numbers examined in all 8 counties were as follows: Kent, MD (34.48 [60.01]n=6); Queen Anne, MD (21.81 [33.94]n=4); Mecklenburg, VA (18.84 [25.33]n=23); Montgomery, VA (30.59 [36.60]n=36); Guilford, NC (71.87 [130.88]n=54); Scotland, NC (36.77 [65.13]n=61); Chesterfield, SC (81.85 [156.98]n=38); and Hampton, SC (41.08 [81.68]n=14). Dove bone lead levels can reflect chronic lead ingestion thereby allowing their use as biological monitors for lead contamination in terrestrial ecosystems. It was interesting to note the relatively high lead levels detected in birds collected from Guilford (X=71.87) N.C. and Chesterfield (X=81.85), S.C. as compared to the other counties. Birds from the Guilford area were associated with a high human population density probably allowing increased lead exposure. Chesterfield doves were obtained adjacent to a major highway system and possibly were ingesting lead contaminated roadside grit particles. Investigations are continuing on the characterization of lead exposure patterns in these birds.

ULTRASTRUCTURAL CHARACTERISTICS OF KIDNEY TISSUE OF RINGED TURTLE DOVES FOLLOWING LEAD INGESTION. R. J. Kendall, L. A. Weiss*, J. A. Twitty* and P. F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Ringed turtle doves (*Streptopelia risoria*) received 0 or 4 x 10 mg lead shot, while maintained on a corn diet, and the toxicology of lead in kidney cells was investigated. The bird receiving lead shot exhibited classical signs of lead poisoning in avians including bile stained vent, lethargy, and emaciation. Upon sacrifice at 2 weeks post-treatment, kidney tissue was obtained from both treatment and control birds and fixed in 10% buffered formalin for histological evaluation. Kidney tissue from both birds were placed in glutaraldehyde and later stained with uranyl acetate for electron microscopic examination. Ziehl-Neelsen acid fast staining revealed intranuclear inclusion bodies in the proximal convoluted tubules of the lead treated bird (100X, 400X, and 1000X). These intranuclear pinkish granules were not detected in control kidney tissue. Ultrastructural examination of these inclusions revealed these granules were in fact not clumped chromatin ($8.3 \times 10^3 \text{X}$) but had a structure consisting of a dense central core and outer fibrillary zone ($33 \times 10^3 \text{X}$). This ultrastructural study of intranuclear inclusion bodies from the same kidney in which inclusions were determined histologically demonstrates the value of histopathology for determination of lead poisoning in doves resulting from lead shot ingestion.

DEMONSTRATION OF A NEW INSTRUMENT (P.S.E.) FOR RESEARCH IN BIOLOGY AND MEDICINE. Michael P. Kradz* and John C. Bartone. American Health Research Institute, Annandale, Virginia 22003.

Preliminary experiments begun in 1971, continue to indicate reliability of the instrument called the Psychological Stress Evaluator (PSE) which was patented in 1976. However, reliability varies with use and training of operators. Some investigators with faulty procedures report negative results. The PSE records stress through voice analysis. Experimental control is very important in order to obtain correct laboratory results. Voice analysis requires proper preparation of person being examined. The questioning or "interrogation technique" must be also carefully designed in each particular case (person, client or suspect), to reduce extraneous factors (often ignored). Analyses of voices properly performed can not only reveal the presence of stress but also in which areas the stress exists. Causes of stress in people are multitudinal and can range from mild upset to hysterical (psychic) trauma. Stress also has an extremely high correlation with wrong-doing, guilty consciences or association with what people consider morally wrong. These factors will be presented by PSE-charts as in cases of drugs, shop-lifting, larceny, theft and assault. Various evidence provides PSE reliability.

PREGNANCY BLOCKING IN RODENTS: ADAPTIVE ADVANTAGES FOR FEMALES. J. B. LABOV*, Dept. of Biology, Washington and Lee Univ., Lexington, Va. 24450.

Recently inseminated female rodents exposed to unfertilized males often terminate pregnancy and return to estrus. Pregnancy blocking may increase male reproductive success and reduce the chance of providing parental investment to unrelated offspring. The adaptive significance for females is unclear.

Pregnancy blocking was studied for possible female advantages. Two hypotheses were tested: 1) Females exposed to socially dominant males will lose pregnancies more often than those exposed to subordinates. Females invest much time and energy in pregnancy, and those which encounter dominant (presumably fit) males may increase their ultimate reproductive success by terminating the pregnancy and remating. 2) Males which are unable to terminate a pregnancy sired by a competitor may kill unrelated offspring and re-inseminate the female. Pregnancy blocking may be a female counter-response to male infanticidal behavior.

Experiments with house mice (*Mus musculus*) showed no differences in pregnancy blocking ability of dominant and subordinate males. However, males killed significantly more unrelated than related offspring. The data are interpreted in terms of female energetics, lifespan, and population social structure. Data in the literature for other mammals and one species of bird are reinterpreted from the perspective of female advantage.

AN ATTEMPT TO ISOLATE INHIBIN FROM OVINE TESTICULAR TISSUE. B. D. LaMar* and R. J. Swanson, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

In an attempt to isolate inhibin from testicular tissue, a supernatant of freshly frozen ovine testicles was prepared through centrifugation. This supernatant, processed through a Concanavalin A/sepharose column, yielded three proteinaceous fractions: (1) non-binding proteins, (2) binding non-glycoproteins, and (3) glycoproteins. Using maturing rats, FSH suppression by these fractions will be tested in a bioassay developed in our laboratory.

LEAD CONCENTRATIONS IN PINE VOLES TRAPPED FROM TWO VIRGINIA ORCHARDS. Robert L. Lochmiller II, Ronald J. Kendall, Patrick F. Scanlon, and Roy L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Pine vole (*Microtus pinetorum*) carcasses were analyzed for lead concentrations. The carcasses were from 105 pine voles which were trapped from 2 orchards. One abandoned (A) and one maintained (M); during 2 months - January and November. Livers and gastrointestinal tracts were removed for other studies. Pine voles were classified by age into juveniles (<7 weeks), subadults (7-10 weeks), and adults (>10 weeks). Mean (\pm S.E.) levels of lead ($\mu\text{g/g}$, d.w.) for all voles (by orchard and by month) were as follows: 31.12 \pm 2.77 (A, Jan.), 20.48 \pm 2.31 (A, Nov.); 25.71 \pm 2.04 (M, Jan.); and 24.74 \pm 3.22 (M, Nov.). Analysis of variance indicated that there were significant effects of month of collection ($P<0.05$) and age of pine voles ($P<0.001$) on lead levels of pine voles. There was a significant ($P<0.05$) interaction between effects of orchard and month of collection on lead levels.

DIGESTIBILITY OF APPLE, FORR AND LABORATORY CHOW DIETS BY MICROTUS PINETORUM. R. L. Lochmiller*, R. L. Kirkpatrick, and J. B. Whelan*. Dept. of Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061.

Twenty-one adult pine voles (*Microtus pinetorum*) were live trapped from orchard habitats in southwest Va. and separated into 3 groups of 7 animals each. Each group was placed on a diet of either apple fruit (pulp only), dandelion leaves (*Taraxacum officinale*), or Purina Laboratory Mouse Chow. Apples and forbs were collected during the month of August and given fresh during the trial. Animals fed a diet of Purina Lab Chow served as the control to which the other diets could be compared. The lignin tracer technique of determining diet digestibility was employed in this study. Lignin concentrations were determined utilizing the permanganate lignin procedure.

Animals on a dandelion diet lost an average of 2 grams, while those on an apple diet lost an average 2.5 grams in body weight during the 5 day digestion trial. Animals on the lab chow diet maintained a constant body weight and in some cases increased in weight. Apple pulp had the highest digestibility coefficient for both dry matter (92.0% \pm 0.7%) (X \pm S.E.) and energy (90% \pm 1.7%). Dandelion had digestion coefficients of 64.4% \pm 9.8 for dry matter and 59.7% \pm 7.9 for energy. Lab chow was determined to have digestion coefficients of 68.0% \pm 1.9 for dry matter and 73.4% \pm 1.1 for energy.

SUMMER FOOD PREFERENCES OF MICROTUS PINETORUM AS DETERMINED BY LABORATORY CHOICE TESTS. R. L. Lochmiller*, R. L. Kirkpatrick, and J. B. Whelan*. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The food preferences of *Microtus pinetorum* were studied during May, 1978 to estimate the potential food supply available to them in apple orchard habitats in southwest Va. Food preferences of voles caught in apple orchards were studied using "cafeteria choice tests" under laboratory conditions. Animals were offered a choice of several freshly clipped foods twice daily. The quantity of each food consumed was determined and then each food item was assigned a preference rank.

Apple fruit was preferred over all other food items (14 items) tested. Among the 10 species of forbs tested, dandelion (*Taraxacum officinale*) appeared to be most preferred, however, the degree of preference of this species was only slightly greater than that of broad-leaved plantain (*Plantago major*) and clover (*Trifolium* sp.). Of all forages tested, grass species tended to be the least preferred. Of the 2 species of grasses tested, Muhlenberg grass (*Muhlenbergia schreberi*) was preferred over orchard grass (*Dactylis glomerata*). When the degree of consumption of forbs was compared to that of grasses, forb species, on the average, comprised 87% of the total diet while grasses made up 13%.

Overall, pine voles appeared to be quite diverse in their feeding habits.

SEASONAL VARIATIONS IN FOOD AVAILABILITY FOR TWO MICROTUS PINETORUM POPULATIONS FROM SOUTHWEST VIRGINIA APPLE ORCHARDS. R. L. Lochmiller*, R. L. Kirkpatrick, and J. B. Whelan*. Dept. of Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061.

Seasonal biomass and energy production of forages available to *Microtus pinetorum* populations were measured in a maintained and an abandoned apple orchard. A 100% clip of live vegetation was made on 24 (1m²) sample plots (12/forchard) for each of the seasons sampled. Apple production was measured by 10 (1m²) soft mast traps in each orchard. Dry matter (DM) and energy (GE) production was determined for each season and orchard.

Production estimates of preferred forages in the maintained orchard were 135.2, 130.9 and 47.3 g/m² of DM and 583.6, 580.8 and 223.7 kcal/m² of GE for the summer, fall and winter, respectively. Production estimates in the abandoned orchard were 24.8, 38.9 and 8.3 g/m² of DM and 108.8, 165.7 and 38.5 kcal/m² of GE for the summer, fall and winter, respectively. Annual apple production was determined to be 205.6 and 127.2 g/m² of DM and 895.1 and 552.5 kcal/m² of GE in the maintained and abandoned orchard, respectively. It was concluded that apple production provided an important energy reservoir for sustaining large pine vole populations through the winter.

THE EFFECT OF THE SOCIAL ENVIRONMENT ON SEXUAL MATURATION OF FEMALE DEERMICE (*PEROMYSCUS MANTICULATUS BAIRDI*). Donna L. Lombardo and C. Richard Terman. Biology Dept., College of William and Mary, Williamsburg, Va. 23185.

Female deer mice were housed from weaning as isolates; with one or five adult males or females; or with groups of five adult males plus five adult females. After 14 days, body, uterine, ovarian and adrenal weights were determined. Body weights of females reared with five males were significantly greater than those of females from the other treatments except for those reared with one male. Females reared with five or more adults of either sex had significantly smaller uteri than paired or isolated females. The ovaries of females reared with grouped adults were likewise smaller in size than those maintained alone or with single animals of either sex, although not at the same level of significance. No clearly defined inhibition or stimulation of sexual maturation dependent upon sex of conspecifics was observed. The interaction of sex and number of conspecifics in regulating female sexual maturation through pheromonal and behavioral cues will be discussed.

TRACE NUTRIENTS IN LOBLOLLY PINE (*PINUS TAEDA*, L.) NEEDLES USING PROTON INDUCED X-RAY EMISSION (PIXE). E. M. Long, E. S. Wise, Christopher Newport College, Newport News, Va. 23601, and G. C. Grant, H. Aceto, Jr., College of William and Mary (Research Campus), Newport News, Va. 23606.

The trace nutrient composition of *Pinus taeda* L. needles has been determined using PIXE. Monthly litter samples were taken (Jan. 1978-Feb. 1979) from three predominantly *Pinus taeda* sites on Bladen type soil. These three sites consist of 90 yr. *P. taeda* on moderately drained soil and *P. taeda* on moderately and poorly drained soil. Techniques have been developed to investigate the nutrient content of these needles with respect to tree age (90 yr versus 9 yr), soil condition (moderate to poor drainage), season (summer versus winter) and live needle versus fallen needle. NBS SRB 1575 was analysed to check for accuracy. Elements determined include: P, S, Cl, K, Ca, Cr, Mn, Fe, Ni, Cu, Zn, Se, Br, and Pb.

TRACE ELEMENT AVAILABILITY IN BLADEN-TYPE SOILS. C. W. Long, E. S. Wise, Christopher Newport College, Newport News Va. 23601. G. C. Grant and H. Aceto, Jr., Coll. of William and Mary (Research Campus) Newport News, Va. 23606.

Three standard soil extraction procedures (1) 0.005 M DTPA (diethylenetriaminepentaacetic acid) (2) 1 M NH_4OAc and (3) 0.050 N $\text{HCl}/0.025$ N H_2SO_4 were compared by analyzing the extracts by Atomic Absorption Spectrophotometry and Proton Induced X-ray Emission (PIXE) to determine trace element availability in Bladen-type soils. Three sites were studied: A site with 90-year-old pines having fair drainage, another site that had been reforested, also having fair drainage, and the third site containing 9-year old pines (reforested) having poor drainage. These sites were compared on a basis of their micronutrient availabilities. A comparison was also made of the elements present in the soil itself versus the extractable elements. Different filtration procedures for the leachate were studied.

SEASONAL EFFECTS OF TEMPERATURE ON THE OXYGEN AFFINITY OF CRUSTACEAN HEMOCYANIN. N.A. Mauro*(Intro. by C.P. Mangum). Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

Although metabolic adaption to temperature has been investigated in decapods (Robert, 1971; Mauro, 1978), the systemic role played by hemocyanin in adapting to seasonal temperature fluctuations is not known. In this study the seasonal effects of temperature on the oxygen affinity of *Callinectes sapidus* hemocyanin were investigated. It was observed that the hemocyanin oxygen affinity of summer animals was higher than winter animals when tested at the same temperature of 25°C. This difference in oxygen affinity results in an increased oxygen transport by the blood which was not reversed by a three week acclimation of summer animals to winter temperatures. By comparison, winter animals are unable to adapt the oxygen affinity of their hemocyanin to winter conditions and therefore exhibit a decreased oxygen transport by their blood for that period of the year.

SOIL LEACHATES AND CULTURING OF *NAEGLERIA* SPP. John D. Mitchell and William H. Yongue, Jr. Dept. of Biology, V.P. I. & S.U. Blacksburg, VA 24061

Soils from the Richmond, Virginia area were used in the preparation of media for the growth of soil amoebae using the soil leachate as the sole source of nutrients. Leachates, in agar, from seven different lakes were used to culture isolates from one of these lakes at 42.0°C. The chemical composition of each leachate was determined using a Perkin-Elmer 460 Atomic Absorption Spectrophotometer. Width of the central-most portion of an inoculation streak was used for relative growth of each culture. Preliminary results tend to suggest a relationship between high magnesium ion concentration and good growth of amoebae. Research is being continued to determine the effects of increasing magnesium ion concentration of leachates on the extent of growth of thermophilic soil amoebae. (Supported by V.P.I. & S.U. Small Projects Grant Program and The Center for Environmental Studies)

ADHESIVE INTERACTIONS OF EMBRYONIC CHICK HEART AND LIVER CELLS IN CULTURE; FIBROBLASTS, HEPATOCYTES, AND MYOCYTES ALONE AND IN COMBINATIONS.

V.J. Macko* and L.L. Wiseman. Biology Dept., Col. of William and Mary, Williamsburg, VA 23185

The fusion, *in vitro*, of two different, small pieces of embryonic tissue generally lead to the partial or total envelopment of one tissue by the other. This behavior is probably mainly dependent upon differences in intercellular cohesiveness, with the less cohesive tissue mass coming to surround the more cohesive mass. For example, embryonic chick liver tissue usually surrounds heart tissue when the two are allowed to fuse in culture. We wondered if the tissues, which behave as discrete types in fusion experiments, might contain adhesively distinguishable subpopulations of cells. By separating suspensions of 11-day embryonic heart and liver cells into populations which stick quickly to plastic (fibroblast-like cells) and populations which do not (myocytes and hepatocytes), we were able to produce four types of "homogeneous" cellular aggregates, each of which displayed different and distinct adhesive behavior when combined with other aggregates in all six possible binary combinations. Each of these embryonic tissues seems to consist of a more (fibroblast) and a less (myocyte and hepatocyte) cohesive population of cells.

INFECTION OF MICE BY *NAEGLERIA FOWLERI* FOLLOWING INTRAVENOUS INOCULATION. R.G. May and D.T. John. Dept. Microbiol., Va. Commonwealth Univ., Richmond, VA 23298.

Investigators have concluded that the natural route of invasion for *Naegleria fowleri* is intranasal (I.N.). The best route for experimental infection would seem to be I.N.; unfortunately, this often is an inaccurate or inconsistent method of inoculation. To avoid using I.N. instillation, and yet obtain similar results, mice could be inoculated intravenously (I.V.). This report describes the course of *N. fowleri* infection in mice following I.V. inoculation. All mice were male DBE/ICR weighing 18-19g. Eight mice were inoculated I.V. with either 10^3 , 10^6 or 10^7 *N. fowleri*. Blood was collected from 5 to 160 minutes after inoculation; results showed that amoebae were cleared from the blood before 5 min, between 5-10 min, and between 120-160 min, respectively. Thirty-two mice were inoculated I.V. with 2.4×10^6 *N. fowleri*; at selected times after inoculation, tissues were obtained for culture and histology. Amoebae were cultured and observed in H&E stained sections from brain (days 1-21), lung (days 1-12), liver and kidney (days 1-5). Infected mice showed slower weight gain, leukocytosis, reduced lymphocyte/neutrophil ratio, neurological symptoms and mortality. Histologically, the disease was characterized by amebic invasion of the brain, hemorrhage, edema, meningeal and perivascular leukocytic infiltration, and necrosis. Mice inoculated I.V. with *N. fowleri* died from meningoencephalitis similar to that observed for mice inoculated I.N.

EUGLENA, TEMPERATURE AND CHROMIUM. Joy Moffitt and William H. Yongue, Jr., Dept. of Biology, V.P.I. & S.U., Blacksburg, VA 24061

Cultures of *Euglena gracilis* received sublethal temperature and acute chromium trioxide treatments. Cultures were first exposed to temperatures of 30C and 34C. There was no evidence of an effect at 30C; however, at 34C individuals rapidly died-off starting at day four when the average number of *Euglena* per cover slip was seven; the initial count was 63.75 per cover slip. By day 10 all *Euglena* were dead. Sublethal temperature was determined to be 31.5C by Yongue et.al. (1979). The effect of chromium trioxide at concentrations of 1000, 100, 10, 1, 0.1, 0.01, and 0.001 mg/l (ppm) were examined at room temperature, after being exposed to 31.5C for one hour and then returned to room temperature and after continuous exposure to 31.5C. Exposure to CrO_3 concentration of 1000 mg/l caused immediate deaths. At concentration of 100 mg/l deaths occurred as early as, after one hour with complete die-off after 24 hours. At concentrations of 10 mg/l there were deaths at 1 hour, with no increased die-off after 3 hours except for the 31.5C continuous treatment. Deaths occurred after 24 hours for 10 mg/l CrO_3 treatments at room temperature.

In a previous study (Yongue et.al. 1979 J. Protozool 26:1) similar experiments were concluded after three hours. The results in this study show that chromium effect may not be apparent in that short a period. This research is being continued.

LONGEVITY IN LAND SNAILS AND THE COST OF REPRODUCTION. James Murray. Dept. of Biology, Univ. of Va., Charlottesville, Va. 22901

Among terrestrial invertebrates, land snails are unusually long lived. The greatest recorded age is for an individual of *Partula taeniata*, collected on Moorea in French Polynesia on 14 August 1962, that lived until 15 March 1979, a life span of at least 16 years and 7 months. A cohort of 31 *Partula taeniata*, maintained in isolation in the laboratory, displayed a Type I survivorship curve, indicating high survival until senescence. Median age at death in this group was 127 months. The cost of reproduction in terms of increased probability of death can be estimated from the survivorship of animals employed in genetic crosses. The reduction in median age at death amounts to at least a year. (Aided by NSF grants GB4188 and GB26382)

RECONSTITUTION OF JELLYFISH POLYPS FROM AGGREGATES OF DIS-SOCIATED CELLS. Gayle K. Riley* and R. F. Black, Col. William & Mary, Williamsburg, Va. 23185.

Suspensions of single cells were prepared from polyps and podocysts by treatment with trypsin. Cells were washed and shaken on a rotator overnight. Polyp cells and a sub-population of podocyst cells reaggregated to form smooth clumps, which subsequently gave rise to polyps. A significant subpopulation of large podocyst cells failed to reaggregate.

Reaggregation was inhibited by the following d-sugars and derivatives at the approximate molar concentrations given: N-acetylglucosamine 10^{-3} , fucose and galactose 10^{-2} , glucosamine, mannosamine and galactosamine 10^{-4} . Glucose and mannose did not inhibit.

The following plant lectins agglutinated cells at the following minimum concentrations (mg/ml): Tetragonolobus purpureus less than 0.1, Triticum vulgaris 0.1, Concanavalin A 0.5. Phytohemagglutinin (*Phaseolus vulgaris*) was ineffective. Lectins clumped even the large podocyst cells which failed to spontaneously aggregate. No difference between polyp and podocyst cells was observed in tests with sugars or lectins.

CONTAMINATION OF FOOD CHAINS WITH PARTICULAR REFERENCE TO VERTEBRATES. Patrick F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Research on environmental contamination in the Dept. of Fisheries and Wildlife Sciences at VPI&SU has involved work with heavy metals and with chlorinated hydrocarbons. Emphasis has been placed on the movement of contaminants in food chains, and on the effects of the contaminants on health and reproduction of vertebrate species. Research to date has centered on the heavy metals, lead, cadmium, nickel, and zinc as they relate to highways; on lead as a contaminant of orchards and of management areas for upland game birds; and several heavy metals as contaminants of waterfowl food sources. Work with chlorinated hydrocarbons has involved work with a PCB, Mirex, and with Kepone. Emphasis has been placed on the effects of heavy metals and chlorinated hydrocarbons on undernourished as well as *ad libitum* fed animals. Funding for some of the research has been provided by DOT and NIH.

TRYPANOSOMA MUSCULI DEVELOPMENT IN CASTRATED AND UNCASTRATED ALBINO (SW) AND BEIGE (BG) MICE. D.K. Sen, G. D. Inman*, and D. Lambert*. Dept. of Life Sciences, Va. State Univ., Petersburg, Virginia 23803

Castrated albino (SW) and castrated beige (BG) mice inoculated with 5×10^4 *Trypanosoma muscui* developed a higher parasitemia as compared to the uncastrated but infected mice in two separate experiments. Effects of different strains of mice on the development of trypanosomes were also examined.

In Experiment I, an average of 36×10^6 cells/ml of blood was observed at the parasitemic peak in the castrated SW mice compared to 22.8×10^6 cells/ml of blood in the uncastrated control SW counterparts. In Experiment II, an average of 66.2×10^6 cells/ml of blood was observed at the parasitemic peak in the experimental castrated beige (BG) mice compared to 46.5×10^6 cells/ml in the uncastrated BG controls.

Of these two strains tested, BG male mice proved to be the superior host for *T. muscui*. An average of 66.2×10^6 cells/ml of blood was observed at the parasitemic peak in the BG mice compared to 22.8×10^6 cells/ml in SW male mice. (Supported by NIH grant S06-RR-08090-07)

EFFECTS OF CHITIN INJECTIONS AND ANTI-CHITIN IMMUNITY ON TICK INFESTATIONS OF RATS. Janet Skinner* and S. B. Ackerman. Department of Biological Sciences, Old Dominion Univ. Norfolk, VA 23508.

In 1971 a United States Patent (No. 3,590,126) was granted to William R. Porter for an anti-tick vaccine consisting of suspensions of chitin (polymeric N-acetyl glucosamine). Mr. Porter claimed that antibodies generated in dogs following one chitin injection would provide long-term *in vivo* protection against ticks and *in vitro* kill fleas and "fender ticks comatose". The present study reports upon attempts to reinvestigate this phenomenon using controlled experimental infestations of rats with the American Dog Tick, *Dermacentor variabilis*. Using several assays we have not been able to demonstrate that rats respond immunologically to crude (ground crab shell) or pure (acid washed) chitin. Although special stains have demonstrated that proteins are associated with the chitin particles, especially the crude chitin, we have not been able to extract the protein using various detergents. Rat hosts were injected with saline suspensions of ground chitin either simultaneously with or several times prior to tick infestation. No differences have been noted between chitin-injected or control animals for attachment, feeding dynamics, or engorgement weights of replete female ticks. Although our investigations are continuing, it appears that for rat hosts chitin is not effective as an anti-tick vaccine.

A PROCEDURE FOR INCREASING RAT HYPOPHYSECTOMY SUCCESS RATES IN ENDOCRINE EXPERIMENTS. R. J. Swanson, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Success rates for complete hypophysectomy of rats is increased from sixty to ninety percent using a glass funnel developed for this procedure. Using a gas flame, a 3/8-inch section of Pasteur pipette is taken at the restriction point and joined to a solid glass rod. A parapharyngeal approach is taken to reach the midsagittal juncture of the occipital and sphenoid bones (OSJ). To maintain tracheal patency, the experimenters inserted a length of plastic Clay-Adams intramedullary tubing of appropriate size for the rat ear being used. In preparation for drilling the burr hole, the capitis muscles were scraped from the basilar occipital bone and the pharyngeal constrictors, originating on the posterior rim of the sphenoid, retracted from the midline. The funnel, doubling as a retractor, allows the investigator to see the midsagittal OSJ and avoid wrapping the adjacent tissue around the spinning burr.

AN ULTRASTRUCTURAL STUDY OF THE MANTLE IN THE OSMOREGULATING CLAM *RANGIA CUNEATA*. R. Turnage* and C.P. Mangum. Dept. of Biol., Col. of William and Mary, Williamsburg, Va. 23185

The macridd clam, *Rangia cuneata*, is able to tolerate a wide range of salinities and has been reported in waters of 0 to 25‰. At salinities below 40‰ it is capable of maintaining its hemolymph hyperosmotic to the surrounding medium and it is thought that the site of osmoregulation is the mantle. This study was initiated to determine if the ultrastructure of the mantle resembles that of other transporting epithelia. Preliminary evidence has shown that both the outer and inner epithelial layers of the mantle have many of the characteristics of transporting tissue.

THE RESPIRATORY ROLE OF CHLOROCRUORIN. G. M. Vogel* (Intro. by C. P. Mangum). Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185

The purpose of the present study was to investigate the respiratory role of the oxygen carrier chlorocruorin in the blood of *Eudistylia vancouveri*, a subtidal annelid inhabiting waters high in oxygen. The effects of carbon monoxide blockage on oxygen uptake was maximal at high P_{O_2} s, and was reduced at low P_{O_2} s. Tube ventilation does not appear to be affected by carbon monoxide. These results suggest that the optimal function of chlorocruorin from *E. vancouveri* occurs at high P_{O_2} s, which is consistent with the exceptionally low oxygen affinity of the molecule.

MIGRATORY BEHAVIOR OF AEDES CANTATOR (DIPTERA: CULICIDAE) IN SOUTHERN MARYLAND. S.C. Weaver and N.J. Fashing. Col. of William and Mary, Williamsburg, Va. 23185

Three *Aedes cantator* (Coquillett) broods were monitored in the vicinity of a salt marsh during 1978. Landing rates and parous rates were determined semi-weekly at four sites extending 2 km inland from the marsh-upland ecotone. In addition, the marsh was frequently inspected for *Ae. cantator* larvae, and a light trap was operated at the marsh edge to detect brood emergences. Data indicate that many females migrate 2 km or more inland after emergence and return to the marsh for oviposition. Parous mosquitoes returned inland for additional blood feeding and no inhibition of migratory tendency was detected.

Landing rates indicate that nuisance persisted several weeks past brood emergence at all sites. Parous mosquitoes were present at all sampling locations during most of the study period, and no significant difference in vector potential was found at any of the study sites. Evidence suggests that *Ae. cantator* migration may be density dependent and serves to reduce both intra- and interspecific competition.

SOME ULTRASTRUCTURAL OBSERVATIONS OF DESMOGNATHUS (CAUDATA, PLETHODONTIDAE) SPERMATOZOEA. J. W. Edward Northam, Jr. and Jerry S. Vande Berg*, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508.

Spermatozoa from the vasa deferentia and testes of *Desmognathus ochrophaeus* were studied with the transmission electron microscope. The emphasis of this study was placed on the cytoplasmic constituents, in particular the cytoplasmic droplet.

The cytoplasmic droplets were limited by a single membrane and located on the side of the axial rod opposite the undulating membrane and flagellum. The droplets were ultrastructurally complex and contained smooth endoplasmic reticulum, ribosomes, myelin-like structures, membrane bound P-bodies and mitochondria. The membrane bound P-bodies contained groups of parallel filaments each about 150 Å in diameter. These P-bodies were present in testicular material but they were more abundant in the cytoplasmic droplets of spermatozoa taken from the vas deferens. Mitochondria in the droplets could be found randomly scattered in the cytoplasmic matrix or grouped into small clusters. Several mitochondria were found attached together by intermitochondrial junctions.

While the spermatozoan cytoplasmic droplet is a highly complex structure, its functional significance remains unknown.

THE INFECTIOUS AGENT OF CYTOTODDIA (=TODDIA BUFONIS). William H. Yongue, Jr., and Katherine A. Booker. Dept. of Biology, V.P.I. & S.U., Blacksburg, VA 24061

The species name *Toddia bufonis* was erected (Francea, 1911. Camara-Pestana, 3:229-238) for a basophilic body with an associated crystal-like inclusion in erythrocytes of a toad. Since then several species of *Toddia* have been described from other species of psittotherms. Harquardt and Yeager (1967, J. Protozoal. 14(4)) proposed that the basophilic body might be a DNA-type virus. Earlier, (Yongue, 1965, J. Elisha Mitchell Sci. Soc.) it had been suggested that the basophilic body was not a protozoan parasite nor was it the infectious agent. Cytotoddia was used as a designation for the general condition seen in blood cells of *Natrix* (=Nerodia) sipedon sipedon.

In 1978, electron microscopy (TEM) revealed widely distributed apparently polyhedral bodies measuring ca. 0.22x0.16µm. Some appeared to be undergoing binary fission. They were not clumped into basophilic masses. To test that the bodies were the infectious agent of cytotoddia, blood cells from a naturally infected water snake (Sip #7) were lysed in distilled water and injected (i.p.) through a 0.45 µm filter into 3 young water snakes with proven negative histories. All showed all characteristics of cytotoddia 14 days post-inoculation.

DYNAMICS OF PROTOZOAN ASSEMBLAGES IN A NEW POND. William H. Yongue, Jr., John Cairns, Jr., and Michael Van Brunt. Dept. of Biology, V.P.I. & S.U., Blacksburg, VA 24061

Polyurethane foam units (PFUs) were used to study the colonization rate of protozoans and the presence of other microscopic organisms in a recently dug pond that is in the early stages of filling. The pond, a unit of the V.P.I. & S.U. Horton Center on Salt Pond Mountain, Giles County, Virginia was specifically dug to be used in aquatic microbial research. This work represents a baseline study. PFUs were anchored in the pond 28 May 1978 and the final units of this set were harvested 6 September 1978; ninety-nine days later. Total hardness, alkalinity and dissolved oxygen were relatively stable but pH increased from 7.5 (Day-0) to 9.3 (Day-99) and CO_2 from 2 to 10 ppm.

The colonization of protozoans increased from 2 species on Day-2 to a high of 26 on Day-22, after which the numbers dropped and oscillated about a mean of 15.2 (N=10; s=3.33). The most common genera were: *Cryptomonas*, *Amoeba*, *Cinetochilum*, *Bursella*, *Stentor* and *Vorticella*.

Other microbiota in PFUs included Rotifera (7 genera), nauplii, Algae (5 genera) *Stenostomum*, *Aelosoma*, *Gastrotrocha* and insect larvae. (A contribution of the Dr. M. C. Horton Aquatic Microbial Laboratory and the Center for Environmental Studies)

Botany

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

SOIL MOISTURE AND THE DISTRIBUTION OF *QUERCUS RUBRA* AND *QUERCUS PRINUS*. Douglas E. Blackman* and Stewart A. Ware, Dept. of Biology, The College of William and Mary, Williamsburg, Va. 23185

Because Keever found in Pennsylvania that *Quercus prinus* occurred in moister sites than *Quercus rubra*, in sharp contrast to conventional wisdom, a study was undertaken of the relationship between the distribution of these two species and soil moisture in the Blue Ridge of Virginia. Two study areas were used; seven stands near Afton Mountain in the north and eight stands near the Peaks of Otter in the center of the Blue Ridge. Stands were selected at different altitudes and with varying degrees and directions of slope. Soil moisture measurements were taken at each stand on a biweekly basis through the growing season using buried gypsum blocks and a Boucouyos moisture meter. In the Peaks of Otter area, *Quercus rubra* stands had much higher average soil moisture than *Quercus prinus* stands. *Quercus prinus* stands also had long periods of consecutive weeks under twenty-five percent soil moisture, unlike the *Quercus rubra* stands. However, the Afton Mountain stands did not have consistent correlations with either the overall soil moisture or the number of consecutive weeks under twenty-five percent soil moisture. The Peaks of Otter data does support the conventional opinion; however, the Afton Mountain data supports Keever's conclusion that there is no consistent correlation between the species and soil moisture.

NEW PLANT DISTRIBUTION RECORDS IN NORTHERN VIRGINIA. Ted Bradley. Dept. of Biology, George Mason University, Fairfax, Va. 22030.

Recent collections of flowering plants from northern Virginia have revealed several unusual records. Species spreading from cultivation and here reported as apparently new for Virginia are *Ornithogalum nutans* (Liliaceae), *Betula pendula* (Betulaceae), *Ulmus parviflora* and *U. pumila* (Ulmaceae), *Erigeron bulbosus* (Asteraceae) and *Floerkea proserpinacoides* (Limnaceae) are reported from near the Shenandoah River in Clarke Co. Northern range extensions in Virginia are *Matelea suberosa* (Asclepiadaceae) from Westmoreland Co., *Ludwigia leptocarpa* (Onagraceae) from King George Co., and *Symplocos tinctoria* (Symplocaceae) from Caroline Co.

MELANTHIUM HYBRIDUM WALT. - A MISAPPLIED NAME. Norlyn L. Rodkin. Dept. of Biology, James Madison Univ., Harrisonburg, VA 22807

Melanthium L. (Liliaceae) is a genus of perhaps eight species with the four species of North America distributed from central Iowa eastward to southern New York, south to northern Florida and eastern Texas. The combination, *M. hybridum* Walt., which has been traditionally used for one of the mid-Appalachian species is a misapplied name not in accordance with the rules of nomenclature. *Melanthium hybridum* was described by Thomas Walter in *Flora caroliniana* in 1788. There are insoluble problems in typifying this ambiguous name, ones relating to both the unassailable original description and the lack of any authentic type material. Walter's description does not fit the species which has been traditionally called *M. hybridum*. References have been made to this erroneous application of the name but the nomenclatural dispositions necessitated by this recognition have not been forthcoming.

The next priorable name for this species is *Melanthium latifolium* Desr. Desrousseaux published this name in 1797 in Lamarck's *Encyclopédie méthodique. Botanique*. The description is very thorough and includes the characteristics commonly attributed to *M. hybridum*. Use of *M. latifolium* Desr. for this species conforms with the rules in the International Code of Botanical Nomenclature and is, therefore, the correct name for this species.

Enzymatic Changes Associated with Juvenile and Adult Forms of English Ivy (*Hedera helix* L.)
B. Budowle and A. Esen, Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061

The two distinct morphological and physiological forms, juvenile and adult, of English Ivy, *Hedera helix*, are more pronounced than in any other woody plant. These two forms provide an ideal model for studying biochemical differences associated with phase change. The enzymes alpha-amylase, catalase, esterase, malate dehydrogenase, and superoxide dismutase have higher activities in juvenile than adult leaves. Conversely, acid phosphatase, glutamate dehydrogenase, peroxidase, and protease activities are higher in adult compared to juvenile leaves. No activities for glutamate-oxaloacetate transaminase, leucine aminopeptidase, monoamine oxidase, and ribonuclease could be detected in either juvenile or adult leaves. In addition, zymograms of the juvenile and adult leaves displayed qualitative differences.

LITTER DECOMPOSITION RATES IN THE DISMAL SWAMP. F. P. Day, Jr. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Leaf litter decomposition rates are being measured by the nylon mesh bag technique in four plant communities in the Dismal Swamp. The communities differ primarily in species composition and frequency and duration of flooding. A preliminary examination of the data suggests that decomposition rates are highest for mixed species litter on the more extensively flooded sites, which also have higher soil and water pH's. Tupelo gum (*Nyssa aquatica* L.) leaves decomposed faster than the other dominant species' leaves, oaks (*Quercus* spp.), cypresses (*Taxodium distichum* (L.) Richard), and Atlantic white cedar (*Chamaecyparis thyoides* (L.) BSP.). Decomposition in periodically flooded swamps appears to be affected by the duration and frequency of inundation.

FLOWER ABUNDANCE, ACORN MORTALITY AND MAST IN WHITE OAK (*QUERCUS ALBA* L.). P. P. Feret and R. E. Kreh. Dept. of Forestry, Virginia Polytechnic Inst. and State University, Blacksburg, Va. 24061.

Several white oak trees aged 37-69 years and varying in height from 18-21 meters were observed for three consecutive growing seasons. Measured were flower and peduncle abundance, flower and fruit periodic mortality during the growing season, and mast production/m² of crown area projected to ground level. Trees that flowered in one year did not always flower. Both "good" and "poor" mast crops were recorded with trees producing from 0 to 6.7 flowers/shoot and from 0 to almost 300 acorns/m². Mortality of flowers from day of pollinations to seed maturation averaged about 70%. A relationship was observed between numbers of flowers at pollination and mast produced by 180 days from pollination.

A COMPARATIVE STUDY OF LITTER FALL RATES IN THE GREAT DISMAL SWAMP, VA. M. Gomez* and F. P. Day, Jr. Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508.

Litter fall rates for four different plant communities in the Great Dismal Swamp, Va. were measured. The four sites differ in dominant vegetation and degree of flooding. The *Taxodium distichum* (L.) Richard community had the highest mean annual total litter fall of 852 gm⁻², followed by the *Chamaecyparis thyoides* (L.) BSP. community with 847 gm⁻², the *Acer-Nyssa* community with 821 gm⁻² and the mixed hardwood (*Quercus*, *Acer*, *Nyssa*, *Liquidambar*) community with 759 gm⁻². Leaf fall as a percentage of total litter fall for each site was 80%, 72%, 86% and 75%, respectively. Annual rates of deposition of wood, fruits and flowers were also estimated. Seasonal inputs of litter were evaluated.

ESTIMATION OF PROTEIN QUALITY AND QUANTITY IN CEREALS.

A. Esen. Dept. of Biology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Alcohol-soluble proteins, prolamines, make up 40-60% of the protein in cereal grains. These proteins are deficient in several essential amino acids, lysine in particular, and render cereals a low quality protein source. A screening method was developed to identify high quality and/or quantity protein cereal mutants. Proteins from whole kernel meals were recovered in two solubility fractions. Fraction 1 includes prolamines, extracted with 60% D-butanol, and Fraction 2, nonprolamines, includes albumins, globulins, glutelins and others, extracted with a high pH buffer containing an ionic detergent (SDS) and a reducing agent (2-mercaptoethanol). Protein content of the two fractions, assayed by a simple dye-binding method, gives an estimate of protein quantity in the sample. The ratio of prolamines to nonprolamines yields an estimate of protein quality. The method offers promise as a simple and rapid mass-screening tool for identifying cereal mutants with high quality and/or quantity protein.

EVALUATION OF HUMIDITY EFFECTS ON LEVELS OF OXIDATIVE ENZYMES IN COTTON LEAF TISSUE. J. G. Foster and J. L. Hess, Dept. of Biochemistry & Nutrition, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Effects of an elevation in humidity from 70% to 95% on levels of soluble protein and activities of oxidative enzymes were evaluated in extracts from *Gossypium herbaceum* L. C.B. 1697 leaf tissue exposed to otherwise typical growth conditions. Light was provided at 200-300 μ E/m² sec during a 16 hr day, and temperature was maintained at 30°. Hoagland's (20%) was provided on alternate days. Leaves, 2-4 weeks of age, were harvested at 24 hr intervals for 5 days following the elevation in humidity. After homogenization, extracts were centrifuged; supernatants were chromatographed on Sephadex G-50; and the soluble protein fraction was assayed for enzyme activities. Decreasing yields of soluble protein/g fresh tissue during the experimental period (~23%) were consistent with symptoms of water accumulation in the leaves and a 30% decrease in the dry weight/fresh weight ratio. Concomitant decreases in glycolate oxidase (~37%) and catalase (~28%) activities on the basis of fresh tissue weight, but not as a function of soluble protein, reflect the increasing contribution of water to fresh tissue weight. An increase in the specific activity of peroxidase (+186%) during the same period suggests a real change in the levels of that enzyme in response to the high humidity and indicates a need to regulate humidity to which plants are exposed during enzyme studies. (Support: CSRS grant # 316-15-93)

THE POLLINATION ECOLOGY OF FOUR NORTH AMERICAN ORCHIDS. J. Hecker*, N.J. Fashing and G.W. Hall, Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185.

The pollination ecology of four North American orchids (*Cypripedium acaule*, *Goodyera pubescens*, *Ponthieva racemosa* and *Tipularia discolor*) was studied in Tidewater, Virginia. During the blooming period of each species, data was collected on flower morphology, phenology and breeding system. The presence of insect visitors, their behavior and their effectiveness as pollinators were also studied.

No insects were observed visiting *C. acaule*, and only six percent of the flowers were pollinated. Although only three halictine and one anthophorine bee were observed visiting *C. pubescens*, 40% of the flowers were pollinated. *P. racemosa* was visited by three hymenopteran families (8 species) and four dipteran families (13 species). Of those capable of effecting pollination, 36% were hymenopterans, primarily Halictidae, and 64% were dipterans, primarily Calliphoridae and Tachinidae. Seventy-eight percent of the *P. racemosa* flowers were pollinated. *T. discolor* was visited by noctuid moths, and 42% of the flowers were pollinated. All four orchids were observed to set seed when artificially self- and cross-pollinated; none appeared to be autogamous. Pollinators visit *P. racemosa* and *T. discolor* to obtain nectar and are probably attracted by odor, although flower color may also play a role.

THE HETEROGENEITY OF SOYBEAN SEED PROTEINS.

B. T. Hu and A. E. Esen. Dept. of Biology, Virginia Polytechnic Inst. & State Univ., Blacksburg, Virginia 24060

Protein components are obtained by exhaustive sequential extraction of defatted soybean meal (Glycine max var Dorman), then subjected to the sodium dodecyl sulfate gradient (10-15%) polyacrylamide gel electrophoresis (SDS-PAGE), isoelectric focusing (IEF) and two-dimensional polyacrylamide gel electrophoresis (2-D PAGE).

365 polypeptides from six different extractions of soybean seeds were separated by 10-15% gradient SDS-PAGE, and 268 polypeptides from four extracts were obtained by IEF. The 2-D protein profiles from water and salt extracts contained over 1000 spots.

YELLOW-POPLAR (LIRIODENDRON TULIPIFERA L.) SEEDFALL AND ACCUMULATION IN AN UNDERSTOCKED BOTTOMLAND SITE ON THE VIRGINIA PIEDMONT. B. L. Kreh* and P. P. Feret. Dept. of Forestry, Reynolds Homestead Research Center, VPI & SU, Critz, VA 24082.

Samples of seedfall and accumulated seed were taken from a bottomland site on Piedmont Virginia. The average number of yellow-poplar stems greater than 5cm in diameter at 1.4m above the ground was 140/ha and the total for this species was 600/ha. The most abundant tree species (but with a very non-random distribution) on the site was Virginia pine (*Pinus virginiana* Mill.) with 624/ha of which 176/ha had stems greater than 5cm in diameter at 1.4m above the ground. Honeyuckle (*Lonicera japonica*) was the dominant understory vegetation with an average cover of 48%. Annual seedfall, ranged from 2.6 million/ha to 10.5 million/ha during the 1978 season. X-ray analysis indicated that an average of 3.8% of the 1978 seedfall contained at least 1 sound seed per samara. Accumulated yellow-poplar ranged from 102/m² to 892/m². The large amounts of seedfall and accumulated seed indicate that seedling is not the limiting factor in yellow-poplar stand establishment on the site studied. *Lonicera* cover and lack of mechanical disturbance were thought to be the primary factors effecting seedling establishment.

FIRST YEAR SURVIVAL AND GROWTH OF *LEUCAENA LEUCOCEPHALA* IN THE REPUBLIC OF HAITI. D. O. Lantagne*, D. Nm. Smith. Dept. of Forestry and Forest Products, Va. Polytechnic Inst., Blacksburg, VA 24061.

In the fall of 1977 seedlings of *Leucaena leucoccephala* and other introduced and native species were planted in four trial plantations within northwestern Haiti. Plantation sites ranged in elevation from 40 meters above sea level to 620 m above sea level on soil types varying in depth, characteristics and slope.

Five replications of at least twelve species occurred in every trial plantation. After ten months *Leucaena leucoccephala* var K-8 showed considerable growth gains across all elevations and soil types where it occurred. Average height growth for the ten month period was 1.85 m at 620 m asl to 3.50 m at 40 m asl.

Leucaena showed great promise for biomass production, use in the charcoal industry, the local wood industry and as an erosion control species.

IN VITRO AND IN VIVO INHIBITION OF POLYPHENOL-OXIDASE ACTIVITY BY BENZOIC ACID DERIVATIVES IN THE TETRASPORE ASCOMYCETE *PODOSPORA ANSERINA* NIESSL. Cynthia A. Manshark*, sponsored by James E. Perham. Randolph-Macon Woman's Coll., Lynchburg, VA 24503

p-Aminobenzoic acid has been shown to inhibit perithecial formation in *Podospora anserina* Niessl, while non-competitively inhibiting tyrosinase activity and stimulating laccase activity. PABA also inhibits the polymerization of melanin.

Several other benzoic acid derivatives were tested for their effects upon the activities of these polyphenoloxidases and upon melanin polymerization and perithecial formation. Enzyme activities were determined by spectrophotometrically monitoring dopachrome formation.

Benzoic acid and its p-substituted derivatives were found to inhibit tyrosinase activity, while its m- and o-substituted derivatives showed no effect. Laccase activity was stimulated by amino-substituted derivatives, but was unaffected by others. Melanin polymerization was inhibited by the amino-substituted derivatives. In *in vivo* tests, only benzoic acid and its p-substituted derivatives inhibited perithecial formation.

SEASONAL PHYTOPLANKTON COMPOSITION IN THE LOWER CHESAPEAKE BAY AND OLD PLANTATION CREEK, CAPE CHARLES, VIRGINIA.

H. G. Marshall, Dept. Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

During a 14 month phytoplankton study in the lower Chesapeake Bay, there was a bi-modal pattern of population peaks with fall-spring maxima. The phytoplankton was dominated by *Skeletonema costatum* and other major diatoms similar to dominants found on the continental shelf. The composition in an adjacent inlet, Old Plantation Creek, was similar throughout most of the period, but differed mainly from Bay populations during the summer months when larger concentrations and diversity of phytoplankton and small sized diatoms occurred. The composition of the phytoplankton is considered estuarine with a makeup characteristic to a turbulent and estuarine setting. A total of 215 phytoplankters were recorded with dominant species common to the upper and lower Chesapeake Bay noted. These were *Asterionella japonica*, and *Skeletonema costatum* in the winter; *A. japonica*, *S. costatum*, *Ceratium*, *Rhizosolenia fragilissima* in spring; *Coscinodiscus marginatus*, *Rhizosolenia calcar avis*, and *Ceratium furca* in summer; *S. costatum* and *Chaetoceros socialis* in the fall.

ABOVE-GROUND PHYTOMASS AND NUTRIENTS IN THE UNDERSTORY VEGETATION IN AN APPALACHIAN OAK FOREST IN SOUTHWESTERN VIRGINIA.

Wayne L. Martin*, Terry L. Sharik, David Wm. Smith, Dept. of Forestry, Va. Polytechnic Inst., Blacksburg, VA 24061

Destructive sampling was undertaken to estimate the contribution of the herb stratum and shrub stratum to above-ground phytomass and nutrients (N, P, K, Mg and Ca) in four different vegetation types in an Appalachian Oak Forest in southwestern Virginia. The study area is located at midslope on the southeast aspect of Potts Mountain in four non-contiguous compartments which are to be clearcut and whole-tree harvested in the near future. A partial random sampling scheme was utilized to select 20x20 m study areas, within which 48 1x1m and 16 5x5m herb and shrub stratum plots were nested respectively. Statistical tests indicated that significant differences in above-ground phytomass and nutrients exist between vegetation types in both strata. The trend is towards greater amounts of understory vegetation on progressively drier sites. Total amounts (kg/ha) of nutrient elements show a similar trend. In contrast, nutrient element concentrations show a reverse trend, with higher concentrations of nutrients found on the more mesic sites. Ordination techniques were utilized to investigate differences in nutrient concentrations among species. Species groupings derived from the ordinations substantiated the sorting of vegetation types along a moisture gradient.

INVESTIGATION OF THE PISTILLATE ONTOGENY OF WHITE OAK (*QUERCUS ALBA* L.) BY SCANNING ELECTRON MICROSCOPY. S. A. Merkle, P. P. Peret*, J. G. Croxdale, and T. L. Sharik. Dept. of Forestry, Dept. of Forestry, Dept. of Biology, Dept. of Forestry, Va. Polytechnic Inst., Blacksburg, Va., 24061.

The ontogeny of pistillate structures of white oak (*Quercus alba* L.) was traced using scanning electron microscopy. It was found that in the Virginia trees sampled, pistillate inflorescences are initiated in late summer in the axils of developing leaf primordia in the bud. These inflorescence primordia show little differentiation before dormancy in October and are difficult to distinguish from lateral bud primordia during their early development. The most mature inflorescence primordia may produce one or two bracts near the inflorescence base by October. By late March, the inflorescence resumes development, adding bracts and enlarging rapidly. In early April, individual pistillate flowers are produced in the bract axils. The pistillate flowers complete virtually all of their structural development, producing a perianth and three carpels, during the three weeks prior to anthesis.

INVESTIGATION OF THE STAMINATE ONTOGENY OF WHITE OAK (*QUERCUS ALBA* L.) BY SCANNING ELECTRON MICROSCOPY. S. A. Merkle, P. P. Peret*, J. G. Croxdale, and T. L. Sharik. Dept. of Forestry, Dept. of Forestry, Dept. of Biology, Dept. of Forestry, Va. Polytechnic Inst., Blacksburg, Va., 24061.

The ontogeny of staminate structures of white oak (*Quercus alba* L.) was traced using scanning electron microscopy. It was found that in the Virginia trees sampled, staminate inflorescences (catkins) are initiated in developing buds in late May. Individual staminate flowers arise on the inflorescence axis in late June or early July as rounded meristematic areas, and mature in an acropetal direction on the axis. By early August, the most mature staminate flowers on the catkin show development of a perianth ring and anthers. Anthers show lobing by late September and all flowers on the catkin are structurally mature before the onset of dormancy in October. The staminate structures resume development in mid-March and the catkins emerge from the buds in early April. The pollen grains are three-lobed and show no conspicuous surface appendages.

PROBLEMS AND POTENTIALS OF DENDROCLIMATOLOGY IN VIRGINIA. R. L. Phipps. Tree-Ring Lab., M.S. 461, U. S. Geological Survey, Reston, Va. 22092.

Recent work in Virginia indicates that growth rings of trees in the humid, eastern deciduous forests can be accurately dated, and, in some cases, ring widths can be correlated with climatic and hydrologic factors. Significant correlations have been found with records of July lake level (Lake Drummond), June-July precipitation (Dismal Swamp), and indices of July drought severity (Northern Virginia). Late spring temperatures and mid-summer streamflow also appear to be significantly correlated with tree growth.

Significant correlation of growth with a single environmental factor, allows reconstruction of that factor from tree-ring data. At the present time relatively few tree-ring records have been obtained which are both climatically sensitive and long enough to permit reconstruction. Such records are difficult to obtain because not enough is known of the species-habitat combinations which yield the most sensitive collections, and because of the relatively few stands of old trees. Sites which result in severe internal water stress in the trees appear most promising. Sites where lack of water limits growth have been shown to contain trees with climatically sensitive ring records. However, in Virginia, sites which to date have produced the most environmentally sensitive ring records are those where overabundance of water has limited growth.

RECONSTRUCTION OF DROUGHT IN VIRGINIA: A DENDROCLIMATIC INVESTIGATION. L. J. Puckett*. Tree-Ring Lab., M.S. 461, U. S. Geological Survey, Reston, Va. 22092

A 230-year record of the Palmer Drought Severity Index (PDSI) was reconstructed for northern Virginia from variations in widths of tree rings. Incremental cores were extracted from eastern hemlock (*Tsuga canadensis* (L.) Carr.) at three locations in northern Virginia. Measurements of annual growth increments were made and converted to indices of growth.

A response function was derived for hemlock to determine the growth-climate relationship. Growth was positively correlated with precipitation and negatively correlated with temperature during the May-July growing season.

Standardized indices of growth were calibrated with the July PDSI. Growth accounted for 24-30% of the PDSI variance. Further regressions using principle components of combined tree growth indices resulted in a small but significant improvement. Greatest improvement was made by extracting principle components of individual tree growth indices thereby accounting for 64% of July PDSI variance in the regression.

Comparison of the results with a 279-year reconstruction from New York showed considerable agreement between low-frequency climatic trends. These results are very encouraging and suggest that network collections throughout the East may yield significant information about patterns of widespread drought.

STUDIES IN THE VIRGINIA RAMNULACEAE. Gwynn W. Ramsey, Dept. of Biology, Lynchburg College, Lynchburg, Virginia 24501

Taxonomic and distributional studies have been in progress on the Buttercup Family in Virginia for several years. Field and Herbarium studies reveal new taxa within this family for the state and some very interesting distribution patterns are noted. Several species are endemic to Virginia and others may be rare, threatened, or endangered. Eighteen (18) genera and sixty-eight (68) species are recorded. There are no Ramnunculaceae recorded for at least one Virginia county. Some nomenclatural changes are necessary.

THE SMALL ARBORETUM-A TEACHING TOOL. Gwynn W. Ramsey, Dept. of Biology, Lynchburg College, Lynchburg, Virginia 24501

An effective arboretum does not have to be large. A small naturally wooded area may be fenced and maintained as an arboretum for the explicit purpose of furthering botanical interest and study. There are multiple possibilities for utilizing the small arboretum which can serve also as a natural meeting ground for Science, History, Art, and Culture in general. Adaptable to all levels of education and degrees of complexity, various studies in the small arboretum may serve as a means of preview, drill, review, enrichment, and/or evaluation; and they may function on an individual and/or classroom basis. Arboretum studies might also arouse interest, cultivate observation and discovery powers, and establish lifelong hobbies. Development, use, and maintenance of the three acre Lynchburg College Arboretum strengthened by a unique arrangement with a Forest Products Industry are topics included in the presentation. Suggestions for kinds of studies within the small arboretum will be made.

PSYCHROPHILIC ALGAE FROM SOUTH VICTORIALAND LAKES. K.G. Seaburg*, B.C. Parker, and R.A. Wharton, Jr. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Investigations of 11 South Victorialand aquatic ecosystems revealed 101 algal taxa, 30 of which 136 clones were isolated into uniaxial cultures. Following gradual acclimation, these cultures were assayed for growth at temperatures from 2-25 C. Four species were psychrophilic, i.e., incapable of growth at 20 C or higher and capable of growth at temperatures below 5 C. The most important algae in terms of biomass in Antarctica, *Nostoc* spp. and *Phormidium* spp., were not psychrophiles; thus, their growth may be limited to microhabitats in which temperatures rise above the ambient air or water temperatures. The role of psychrophiles may be most important within the plankton community. Soil and littoral benthic algae from these ecosystems were mostly small cosmopolitan taxa which are known to be easily dispersed by wind.

THE STATUS OF THE ENDANGERED VIRGINIA ROUND-LEAF BIRCH, *BETULA UBER* (ASHE) FERNALD. Terry L. Sharik, Robert H. Ford*, Peter P. Ferett., Dept. of Forestry, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Since its rediscovery in August 1975 the single known natural population of *B. uber* has declined somewhat, mainly due to vandalism. It now consists of 20 individuals in the wild, 11 of which are reproductively mature. The *Betula* uber Protection, Management and Research Co-ordinating Committee was created in 1977 to aid in protection and recovery of the species. Protective retaining fences, public information programs, and propagation methods have been established under the Committee's guidance. Current research is aimed at elucidating the ecology, genetics and evolutionary affinities of *B. uber*. A long-term Recovery Plan will be developed within the upcoming year in cooperation with the Endangered Species Office of the U. S. Fish and Wildlife Service. The ultimate objective of the plan is to increase the number of individuals in the wild to a point where *B. uber* can be discharged of its present status as an endangered species.

CONTROL OF FUSARIUM WILT OF TOMATO WITH CYCOCEL® AND LIGNANSAN BLP®. C. A. Spoor, R. J. Stipes, D. M. Orcutt and R. W. Tillman. Dept. of Plant Pathology and Physiology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

Greenhouse-grown tomato plants artificially inoculated with *Fusarium oxysporum* f. sp. *lycopersici* were treated by soil drench with 100 µg/ml Cycocel® (2-chloroethyltrimethylammonium chloride) and/or 500 µg/ml Lignasan BLP® (methyl 2-benzimidazolecarbamate phosphate). The chemicals were applied one week after, one week after, and one week before and after inoculation in Experiment 1 and one week or one and two weeks after inoculation in Experiments 2 and 3. Disease control was evaluated by external symptom expression, height, shoot dry weight, root dry weight, total (shoot and root) dry weight, and the presence of the pathogen in the stem. Plants receiving treatments containing Lignasan BLP® showed good control. Plants treated with Cycocel showed little, if any, control. Growth of the pathogen on Cycocel® amended glucose yeast extract agar was not inhibited at concentrations of 50, 100, 500, 1000 or 2000 µg/ml.

COMPARATIVE DISTRIBUTION OF ARBOTECT 20-S®, CGA 64251, LIGNANSAN BLP® AND NUARIMOL IN *Ulmus americana* FOLLOWING ADMINISTRATION WITH A STERRETT-CREAGER MINIATURE PRESSURE INJECTOR. P. A. Truax, R. J. Stipes and R. W. Tillman. Dept. of Plant Pathology & Physiology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

Two studies (I & II) were conducted to determine the distribution profiles in *Ulmus americana* of A = Arbotect 20-S® (2-(4-thiazolyl)-benzimidazole hypophosphite), C = CGA 64251 (chemistry not divulged), F = fenarimol (α-(2-chlorophenyl)-α-(4-chlorophenyl)-5-pyrimidine methanol), L = Lignasan BLP® (methyl 2-benzimidazolecarbamate phosphate) and N = nuarimol (α-(chlorophenyl)-α-(4-fluorophenyl)-5-pyrimidine methanol). In I, A, F & L were administered at 8,000 µg/ml by gravity flow to 12-yr-old trees in Sept., 1977. Trees were sacrificed and bioassayed 1 mo. later by overspraying biopsy disks with *Ceratocystis ulmi* or *Glomerella cingulata*, and fungal growth inhibition was estimated from the total area of the disc cross-sections. Fungitoxicant distribution varied greatly and may indicate non-uniform protection or therapy. In II, 8-yr-old nursery elm branches were pressure-injected during summer, 1978, with known quantities of A, C, L & N at 5,000 µg/ml using the Sterrett-Creager mini-injector. Branches were bioassayed 2 mo. after injection and similar non-uniform distribution patterns were found. Results of I & II demonstrated inadequacies associated with Dutch elm disease control due to erratic and unpredictable fungitoxicant movement.

A SYSTEMATIC SURVEY OF SELECTED GENERA OF THE TRIBE HELIANTHEAE IN VIRGINIA. S. von Oettingen. Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185

This study is a systematic treatment of a portion of the Heliantheae which is considered to be the most primitive tribe of the family Asteraceae. Nine genera [Iva L. (3 sp.), Ambrosia L. (3 sp.), Xanthium (2 sp.), Helianthus Pers. (1 sp.), Elytista L. (1 sp.), Tetragone-theca L. (1 sp.), Rudbeckia (5 sp.), Echinacea Moench. (3 sp.), Ratibida Raf. (1 sp.)] were examined. Data was obtained from examination of over 800 specimens from seven herbaria, from observations and extensive collections made in the field, and from the literature. Voucher specimens have been deposited in the herbarium of the College of William and Mary. Keys to the genera and species, descriptions, ecological data, and county-based distributional information are included.

COMPARATIVE STUDIES OF AQUATIC ECOSYSTEMS IN SOUTH VICTORIALAND, ANTARCTICA. R.A. Wharton, Jr.*, B.C. Parker, and K.G. Seaburg*. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

During the first austral summer (1977-78) of the project "Ecosystems Comparisons of Oasis Lakes and Soils (ECOLS)", one river and 10 lakes were investigated in the largest oasis or ice-free area on the Continent. While these aquatic bodies are separated by less than 80 km and are subjected to similar climatic regimes, they exhibit a striking range in their physiochemical and biological properties. Based on algal species diversity, phytoplankton biomass, development of a food chain, and such measurements as carbon-14 primary productivity, ATP, chlorophyll a, and water chemistry, Lakes Fryxell and Vanda represent the highest and lowest trophic states respectively. Reasons for these differences include the proportion and chemical composition of glacial meltwater entering these lakes, especially the phosphorus concentration.

In the second austral summer (1978-79) of the ECOLS project, spatial and temporal changes in Lakes Fryxell and Hoare were monitored. Preliminary findings suggest that Lake Fryxell is more productive than Lake Hoare. An under-ice SCUBA reconnaissance revealed an extensive benthic, columnar algal mat community which may dominate the biogeochemical activity in these two lakes.

DETECTION OF BENOMYL-RESISTANT *VENTURIA INAEQUALIS* AND *PENICILLIUM* SP. ON APPLES IN VIRGINIA. K. S. Yoder, Dept. of Plant Path. & Physiology, VPI & SU, Winchester Res. Lab., Winchester, VA 22601.

Benomyl-resistant strains of *Venturia inaequalis* and *Penicillium* sp. were first detected in Virginia in 1978 and in 1977 respectively, on potato dextrose agar amended with 5 ug/ml benomyl. Uninhibited spore germination and mycelial growth on this medium indicates at least a ten-fold decrease in sensitivity to benomyl compared to normal sensitive strains of the two fungi. Alternate non-benzimidazole registered fungicides are recommended for apple scab control in the Smyth County area where resistant *Venturia inaequalis* was isolated, and for blue mold control in Frederick County apple storages where the resistant *Penicillium* sp. was detected.

ISOLATION OF A *PESTALOTIA* SP. FROM GRAPE CANE CANKERS IN VIRGINIA. K. S. Yoder, Dept. of Plant Path. & Physiology, VPI & SU, Winchester Res. Lab., Winchester, VA 22601.

A *Pestalotia* sp. was isolated from two vineyards in Frederick and Rappahannock Counties, Virginia. Consistent isolation of the fungus from surface-sterilized woody cankers and green cane lesions implicates pathogenicity of an organism not previously reported from grape in Virginia.

Cross sections of woody cane cankers from which the *Pestalotia* sp. was isolated revealed a V-shaped penetration of the fungus into the wood. The most common green cane symptom was a slightly sunken necrotic lesion.

STUNTING OF GOLDEN DELICIOUS/M.26 APPLE TREES IN ASSOCIATION WITH RED DELICIOUS TREES EXHIBITING GRAFT UNION NECROSIS AND DECLINE SYMPTOMS. K. S. Yoder, Dept. of Plant Path. & Physiology, VPI & SU, Winchester Res. Lab., Winchester, VA 22601.

A decline of vigor of 6 yr old Smoothee Golden Delicious/M.26 apple trees was observed in the corresponding location of the tree row immediately adjacent to Red Delicious/MM 106 trees exhibiting graft union necrosis, symptoms previously associated with infection by Tomato Ringspot Virus. The proximity of the series of trees exhibiting these symptoms in adjacent rows suggests that the symptoms may be related to a common cause. Populations of *Xiphinema americanum* nematodes, a known vector of Tomato Ringspot Virus, were 10 per 100 cc of soil from the affected tree root zone and 29 per 100 cc of soil from the grass-alfalfa cover crop in the drive row of the orchard.

Chemistry

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

THE SYNTHESIS OF AROMATIC α,α -DIFLUOROISOCYANATES.

C. B. Amann*, J. W. Thompson and A. F. Clifford. Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Carbonyl fluoride will add to a nitrile in the presence of anhydrous hydrogen fluoride with mercuric fluoride present as a catalyst. By this method we have synthesized several aromatic mono and di α,α -difluoroisocyanates and urethanes.

GROWTH OF CRYSTALS IN GELS. Toni A. Ayers* and P. G. Barber. Dept. of Natural Sciences, Longwood College, Farmville, Va. 23901

This study is the beginning of a search for ways to grow crystals suitable for structural studies on substances that do not readily crystallize or that do so with imperfections such as twinning. The methods used include modifications of growth from solution and growth in gels.

In the usual method of growing crystals from solution the crystal is supported by the bottom of the glass container or by a thread suspended from the lid or from a cobra submerged in the liquid. The latter method does eliminate the wick effect caused by the thread, but both of these solution methods leave a string in the crystal. An improvement was developed which connected a seed crystal directly to a fine glass capillary. Large, easily mounted and manipulated crystals resulted.

To eliminate the additional problem of twinning and habit modification by glass barriers, silicate gels were used to grow crystals in gels. This process allows the crystals to grow slowly and regularly.

THE STABILITY OF THE 28S-5.8S COMPLEX FROM RAT AND CHICKEN. N. Banerjee* and T. O. Sitz. Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508.

The large subunit of eukaryotic ribosomes contains 5.8S rRNA, which is hydrogen bonded to the 28S rRNA. This interaction occurs through the 3' end of the 5.8S rRNA and a complementary region of 28S rRNA. Isolated 5.8S rRNA can interact to form dimers or multimers. There is only a three nucleotide difference in the chicken and rat sequence, however the optimum temperature for dimer formation and stability is significantly different. The rat dimer had a T_m about 5° higher than the chicken dimer (Biochem. 17, 5811).

Currently we are comparing rat and chicken 28S-5.8S complex to examine the thermal stability of these interactions. In 0.15M Na^+ , the T_m for both of them is around 55°. In order to detect small differences in T_m , non-radioactive chicken and ^3H -labeled rat complex will be mixed and the T_m of both determined simultaneously.

PARTIAL IDENTIFICATION OF THE COMPONENTS OF THE CRUDE LIPID EXTRACT OF CHRYSOORA QUINQUECIRRHA. Charles E. Bell, Jr., Thomas J. Haas, and Donna L. McGovern. Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA 23508.

The lipid extracts of the jellyfish *C. quinquecirrha* were separated by TLC and analyzed by capillary Column Gas Chromatography. Evidence is presented which confirms previous work that indicates prostaglandins are present. Other lipid classes are identified.

ADDITIVE NMR CHEMICAL SHIFT PARAMETERS FOR DESHIELDED METHINE PROTONS. Deborah Bowles and Harold M. Bell, Dept. of Chemistry, V.P.I. & S.U., Blacksburg, Va. 24061.

The use of additive parameters for the prediction of NMR chemical shifts is widely practiced. However, existing correlations do not give satisfactory results when applied to highly deshielded methine protons, for these protons invariably give calculated chemical shifts which are considerably larger than the experimental values.

In this work, methine chemical shifts have been studied using multiple linear regression analysis in an effort to determine under what limiting circumstances the additivity of shift parameters can be expected to apply. A literature survey uncovered approximately 500 methine chemical shifts, 200 of which have been subjected to computer analysis. As expected, it was not possible to satisfactorily explain all methine chemical shifts with a single set of substituent parameters. However, if only the deshielded methine cases were considered (H-CXYZ, where at least two of the groups are electron-withdrawing), a much better set of parameters could be determined. Our best results thus far show a standard error of estimate of 0.27 ppm, for protons spread between 3 and 7 ppm, involving 20 different substituents.

TIME-DEPENDENT FOCUSSED OF THE TIME-OF-FLIGHT MASS SPECTROMETER. J. A. Browder and G. Sanzone. Dept. of Chemistry, VPI & SU, Blacksburg, Va. 24061.

Recently, data has been collected on the focussing of a time-of-flight mass spectrometer with time-dependent fields. All of the parameters of the Impulse-Focussing-Field Theory were varied systematically. Test of the validity and practical utility of the theory as found in these studies will be presented.

PURIFICATION AND CHARACTERIZATION OF A SERUM MODULATOR OF IRON FLUX FROM STORAGE TISSUES. Melissa P. Calisch* and Richard W. Topham, Department of Chemistry, University of Richmond, Virginia 23173.

Strong evidence suggests that blood serum ferroxidases (ceruloplasmin and Ferroxidase II) promote the formation of Fe(III)-transferrin and thereby stimulate the turnover of iron from tissue stores. Ceruloplasmin is the major ferroxidase in human serum; however, Ferroxidase-II accounts for an increased proportion of the activity in less highly developed animals. A potent inhibitor of both serum ferroxidases has been isolated from whole rabbit serum and purified to homogeneity. It has been identified as a protein composed of a single polypeptide chain with a molecular weight of 6.0×10^4 . Another compound of comparable inhibitory action has been identified, isolated, and partially characterized from whole human serum. Since the rabbit and human proteins inhibit both serum ferroxidases, they could serve as naturally occurring modulators of these enzymes and thus they could regulate the flux of iron from storage tissues. (This work was supported by USPHS Grant 1 ROI AM20148 from the National Institute of Arthritis, Metabolism, and Digestive Diseases).

THE MICROWAVE SPECTRUM OF $\text{CH}_3\text{SiH}_2\text{PH}_2$. R. O. Carter, Dep't. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508, and J.R. Durig, M. Jallian, Y.S. Li, Dep't. of Chemistry, Univ. of South Carolina, Columbia, S.C. 29208.

The microwave spectrum of methylphosphinosilane has been recorded from 18.5 to 40.0 GHz. Two sets of a-type transitions have been observed and assigned with the stronger lines being attributed to the *trans* conformer and the weaker ones to the *gauche* conformer. The rotational constants obtained for the *trans* form are: $A = 16094$, $B = 3904.30$, and $C = 3325.58$ MHz and for the *gauche* form: $A = 16048$, $B = 3806.07$, and $C = 3251.97$ MHz. Splitting was observed for both sets of transitions and was attributed to the coupled internal rotation of the symmetric and antisymmetric rotors. The structural parameters needed to fit the B and C rotational constants indicate a rather short Si-P bond distance of 2.10 Å. Because of the splitting it was not possible to obtain values for the dipole moments. Relative amounts of the two conformers were found to be consistent with those obtained from the vibrational study.

ON THE ISOKINETIC EFFECT. Do Ren Chang, Dept. of Chemistry, Averett College, Danville, Va., and George Sanzone, Dept. of Chemistry, VPI&SU, Blacksburg, Va. 24061.

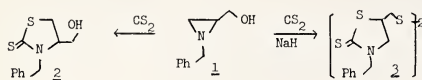
The temperature-dependencies of the rates of both unimolecular and bimolecular reactions are found to correlate. This correlation is presented in terms of a Reaction-Temperature function which should have considerable pedagogical value. Using this function, the construction of a reaction surface leads to a clear picture of the significance of linear enthalpy-entropy correlations. The existence of an isokinetic relationship will be discussed in this context.

PHOTODEGRADATION OF POLY(N-VINYLCARBOZOLE). R. F. Cozzens and W. R. Mindak*, Dept. of Chemistry, George Mason University, Fairfax, VA. 22030.

Poly(N-vinylcarbazole) PVCz is a well known photoconductive polymer with industrial application in the electro-photographic industry. As a photoconductive material its electrical properties are controlled by certain impurities either purposely doped into the polymeric matrix, fortuitously present or produced by degradation during use or manufacture. Photoelectrical activation spectra measured in our laboratory indicate that the first, second and third excited singlet state may lead to generation of photo-carriers. Photochemical degradation is found to result from the lowest triplet state of the carbazole chromophore and may be quenched by transfer of triplet energy to acceptors such as perylene and naphthalene. Stern-Volmer plots in fluid solution indicate quenching of photooxidative yellowing by these triplet acceptors. The nature of various degradation products, their mechanism of formation and effect on photoconductivity is discussed.

AZIRIDINE - CARBON DISULFIDE REACTIONS. S. Clough, R. Solomon† E. Crews.* Department of Chemistry, University of Richmond, Virginia 23173. A. Johnson; L. Jacques* and J. Forehand; A. H. Robins Company, Richmond, Virginia 23220.

The reactions of 1-benzyl-2-hydroxymethyl aziridine (1) with carbon disulfide have been investigated under both neutral and basic conditions. The structures of the products, 2 and 3, have been assigned on the basis of spectral data which are discussed. Mechanisms for these transformations are discussed in light of the results of deuterium labeling experiments.



DETERMINATION OF FORMATION CONSTANTS FOR NUCLEOTIDE-POLYAMINE COMPLEXES. A LABORATORY EXPERIMENT. R. I. Elliott* and W. B. Voigt. Dept. of Chemistry, James Madison Univ., Harrisonburg, Va. 22807

We have developed a laboratory experiment which uses an anion exchange resin method to determine the formation constants for nucleotide-polyamine complexes. The experiment, which is adapted from the work of Nakai and Glinnsman (Biochemistry 16, 5636 (1977)), is appropriate for a biochemistry or biologically oriented physical chemistry laboratory course.

Reaction mixtures, which contain an adenine nucleotide, several concentrations of putrescine, and Dowex AG1-X2, are incubated to allow nucleotide-putrescine complexation. This complex remains in solution, while uncomplexed nucleotide occurs both free in solution and adsorbed to the insoluble anion exchange resin. The total nucleotide concentration in the supernatant of each reaction mixture is determined spectrophotometrically. Treatment of these data by the graphical method of Nakai and Glinnsman, which compensates for the presence of uncomplexed nucleotide in the supernatants, yields the formation constants for the complex.

THE DETERMINATION OF TRACE ELEMENTS IN HUMAN TEETH BY PROTON INDUCED X-RAY EMISSION (PIXE). G. C. Grant, College of William and Mary (Research Campus), Newport News, Va. 23606 and L. D. Fretwell, Dept. of Community Dentistry, MCV/VCU, Richmond, Va. 23298.

Lead in human teeth has been positively correlated with environmental exposure in childhood lead poisoning but most studies have not reported the concentration of other trace elements present in the same teeth. Other trace elements have been correlated in epidemiological studies with the degree of susceptibility to dental caries. PIXE, a modern multielemental technique, was used to study all elements from aluminum (Z=13) to uranium in non-carious teeth with the finding that Fe, Zn, Sr, Sn and Pb were the most abundant trace elements. Teeth were dissected to determine elemental distributions in outer enamel, inner enamel (DEI), secondary (root) dentine, secondary (coronal) dentine and outer dentine finding highly significant variations. Multiple extractions were also analysed to determine the elemental variation between different tooth types from the same individual, also finding highly significant variations.

THE ISOLATION AND IDENTIFICATION OF A UNIQUE NATURAL PRODUCT FROM THE SEEDS AND PODS OF *AILANTHUS altissima*. John R. Cooper and Samuel J. Gamble, Dept. of Chemistry, Lynchburg College, Lynchburg, Virginia 24501

From the seeds and pods of *Ailanthus altissima*, by a systematic non-polar extraction, a saponifiable lipid has been isolated. The extraction technique has also produced a non-saponifiable solid lipid to be identified. Various other organic constituents cited in the literature pertaining to *A. altissima* have also been confirmed.

THE ANALYSIS OF S-ADENOSYLMETHIONINE AND S-ADENOSYLMHOMOCYSTEINE IN TISSUE CULTURE CELLS. K. E. Godburn*, J. M. Keller*, and T. O. Sitz. Dept. of Chem. Sciences, Old Dominion Univ., Norfolk, VA 23508.

Ribosomal RNA isolated from cancer cells has low levels of 2'-O methylation when compared to normal cells although the methyltransferases responsible for the post-transcriptional modification have elevated activities. Similar results for the base methylation of transfer RNA have been reported. One possible explanation for this paradox is that an inhibitor of the methyltransferase reaction accumulates in tumor cells resulting in hypomethylation which stimulates the tumor cells to produce excess enzymes in an attempt to compensate for the low methylation levels. The product of the methyltransferase reaction, S-adenosylhomocysteine, has been shown to have a low K_i for specific methyltransferases. It will be important to correlate the concentrations of both the substrate, S-adenosylmethionine, and the product, S-adenosylhomocysteine, with the methylation level of RNA in various tissues. These levels can be determined with either high-pressure liquid chromatography using a VYDAC cation exchanger (Vicol. 89,494) or sulfopropyl Sephadex, a strong cation exchanger (Anal. Biochem. 91,516) to obtain rapid resolution and quantitative recovery of SAM and SAH from the other components. We are currently investigating the best procedure to examine SAM and SAH concentrations in a variety of tissue culture cells.

MARINE STEROLS FROM THE JELLYFISH, *CHRYSAORA QUINQUECIRRHA*. Thomas J. Haas and Charles E. Bell, Jr., Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA 23508.

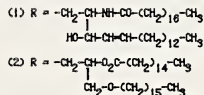
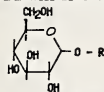
A lipid extract of the jellyfish *C. quinquecirrha* was fractionated on a silicic acid column. Sterols were eluted with methanol-chloroform using a gradient from 2% to 10% methanol. Fractions were analyzed by gas chromatography. Peaks were identified by relative retention times (a) using cholesterol as an internal standard. Tentative identifications are: 22-dehydrocholesterol (a=90), 24-methylcholesterol (a=1.30), and 24-ethylidene cholesterol (a=1.65). Also found were sterols with relative retention times of 1.10, 1.15, and 1.40. These assignments have not been made.

SEMINOLIPID: A POTENTIAL OPIATE RECEPTOR

MODEL. D. G. Hand*, R. L. Williams and D. Brase*, Dept. of Chemical Sciences, Old Dominion Univ., and Dept. of Pharmacology, Eastern Va. Medical School, Norfolk, VA. 23508.

Cerebroside sulfate, CS(1), has recently been shown to bind opiate drugs and therefore satisfy some of the requirements for action as an opiate receptor. Seminolipid, SGG (2), a novel sulfated galactoglycerolipid that can be isolated from the testis of a variety of animals may be viewed as a structural analog of CS. In view of this close structural similarity, we have initiated an original study to determine whether SGG may possess the unique opiate binding quality of CS.

This paper will deal with the method of isolation of SGG from boar testis and its subsequent purification and identification by chromatographic and spectral methods. A technique to study the opiate receptor-like action of SGG will also be discussed.



AN IMPROVED METHOD OF COLORIMETRIC DETERMINATION

OF AMMONIUM ION Daniel J. Carucci, David H. Harpole, Jr., Jerome E. Kahn, John C. Kisalus, Edward U. Kissel, III, Lucien T. Megna, Michael A. Pleva, and James K. Shillington, Dept. of Chemistry, Washington and Lee University, Lexington, Virginia 24450.

The most common technique for determination of ammonia in natural waters is the Berthelot method, or some variation of it, in which a blue color is produced from the indophenol chromophore. Patton and Crouch, [Analytical Chemistry, 49, (1977)], showed that the formation and stability of the chromophore is very dependent on the catalyst/ammonia ratio. We have shown that nitrite in natural waters can react with the catalyst, thereby affecting the catalyst/ammonia ratio and resulting in incorrect ammonia values. However, it was also found that the addition of potassium phthalate, under the proper conditions, resulted in accurate ammonia determinations. The inherent deficiencies of other methods for the colorimetric determination of ammonia and the mechanism by which potassium phthalate corrects them are discussed.

NEW APPROACHES TO THE SYNTHESIS OF INDOL-4,5-QUINONES. II. Jane L. Marcus* and James B. Patrick, John Baker Daffin Laboratory of Chemistry, Mary Baldwin College, Staunton, Virginia 24401.

In cases where oxidation by Fremy's Salt (potassium nitrosodisulfonate) is inapplicable the oxidation of 5-hydroxyindoles to indolo-4,5-quinones has been effected by a variety of methods, none of which seem to be of general applicability. We have continued our previously reported work on nitrosation of 5-hydroxyindoles at the 4-position and now report these experiments and also studies on an alternative; diazo coupling of 5-hydroxyindoles. Phase-transfer catalysis of Fremy's Salt oxidation by Adogen 464[®] is also described.

SYNTHESIS OF N,N'-DISUBSTITUTED-PARA-PHENYLENEDIAMINES.

Paul D. Henson, J. Michael Williams*, and Kenneth A. Cole*, Dept. of Chemistry, Roanoke College, Salem, Va. 24153

Condensation reactions between aniline and p-aminophenol (PAP) and aniline and hydroquinone (HQ) have been examined for the preparation of N,N'-diphenyl-p-phenylenediamine. PAP was found to be slightly superior to HQ in condensation reactions carried out in the presence of ferric chloride and phosphoric acid catalysts. Phosphoric acid proved to be a poor catalyst for the reactions.

Similar reactions of PAP with aromatic amines such as the various toluidines and xylylenes were employed to prepare a variety of N,N'-diaryl-p-phenylenediamines. (This work was supported by Howard Hall and Co., Cos Cob, Conn.)

RECENT ADVANCES IN THE RESEARCH OF TOBACCO

FLAVOR. Robert M. Ikeda*, Philip Morris Res. Ctr., Richmond, Va. 23261

Procedures used in the isolation and identification of the volatile flavor constituents of tobacco are reviewed.

Investigations of Burley, Bright and Oriental tobaccos have revealed the presence of a number of compounds which appear to be breakdown products of isoprenoid material. Selected constituents identified in tobacco and their structural relationships to carotenoids and the diterpenoids of the labdanoid and thumberganoid series are discussed.

Methodology for determining the important components of flavor are explained.

SPECTROSCOPIC CHARACTERIZATION OF CHITIN.

Carolyn J. Jewell* and James P. Wightman, Chem. Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The chitinous materials, chitin, chitosan and natural chitin have been characterized by scanning electron microscopy (SEM) with energy dispersive analysis of X-rays (EDAX), infrared spectroscopy (IRS) and electron spectroscopy for chemical analysis (ESCA). The SEM photomicrographs show similar surface morphology for chitin and chitosan but different for natural chitin. All three solids show a significant calcium EDAX signal. Transmission infrared spectra of KBr pellets of the three chitinous polymers show absorption bands unique to each material. Eight bands in the 3600-465 cm⁻¹ region were common to all three polymers. However, natural chitin contained no peaks at 2150, 1560, 1380, 1330 and 1260 cm⁻¹. Chitosan contained no peak at 955 cm⁻¹. Narrow scan ESCA spectra of the powdered solids were obtained for the C 1s, O 1s, N 1s and Ca 2p photopeaks. The binding energies of the N 1s and Ca 2p photopeaks were equivalent for the three polymers. However, the binding energy for the O 1s in chitosan was 1 eV higher than in chitin and natural chitin. [The advice and help of Mr. Peter Perceval is acknowledged gratefully.]

THE SYNTHESIS OF ALIPHATIC α,α -DIFLUOROISOCYANATES.

J. C. Johnson*, J. W. Thompson* and A. F. Clifford. Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Carbonyl fluoride is a by-product formed in the reaction of fluoroformylmino sulfur difluoride and silver difluoride. We have attempted to find a use for carbonyl fluoride and have found that it will react with nitriles in the presence of anhydrous hydrogen fluoride. This reaction is exceedingly slow; however, it can be accelerated by use of a catalytic amount of mercuric fluoride. Employing this method, we have synthesized several new aliphatic mono and di α,α -difluoroisocyanates.

VIBRATIONAL SPECTRA OF SEVERAL BARBITURATES AND BARBITURATE ANALOGUES. Carol Karnas and R. O. Carter. Dept. of Chem. Sciences, Old Dominion Univ., Norfolk, VA 23508.

It was the purpose of this study to investigate a method with potentially greater specificity than presently used techniques in differentiating between various illicit drugs and their isomers. Raman spectroscopy was chosen because of its selectivity and sensitivity which can equal or exceed that of infrared spectroscopy.

Willis, Cook and Jankov have used this tool for the differentiation of various barbiturates. Confirmation of some of their work has been obtained in this study. The spectra of several of the same barbiturates were obtained using a Spex Laser Raman Spectrometer. In addition frequencies have been recorded so that more exact correlations could be made.

Group frequencies among the barbiturates will be discussed. In order to further characterize the group frequencies among the barbiturates, vibrational assignments of the Raman and infrared frequencies of the symmetric molecules, isocyanuric acid and barbituric acid will be made, hopefully in time for the conference.

TRACE AMINE ANALYSIS OF BIOLOGICAL SAMPLES USING HPLC.

R. L. Williams and Thais Keegan, Department of Chemical Sciences, Old Dominion Univ., Norfolk, VA 23508.

Phencyclidine (PCP) is an anesthetic with psychotomimetic properties which has gained increased interest since its appearance as an illicit street drug. Attempts to explain the prolonged effects of the drug as a function of its blood and tissue levels have been inconclusive. Evidence suggests that PCP is a competitive inhibitor of biogenic amine uptake. Previously, analyses have been limited by detection capabilities. A reverse-phase HPLC procedure allows separation of the *o*-phthalaldehyde derivatives of 18 biogenic amines and polyamines on a μ Bondapak/ 18 column using methanol-acetic acid as the mobile phase. Using 3,4-dihydroxybenzylamine as an internal standard, levels as low as 100 picograms can be quantitated by continuous-flow fluorescence monitoring of the eluate.

Comparative changes in biogenic amine levels in rat brain can be monitored as a function of time and of drug dose for PCP and selected analogues. In addition, the interrelationship of the amines in the central nervous system can be studied.

PREDICTING THE PRODUCTS OF INORGANIC REACTIONS - AN EXAMPLE OF CADAL.

Jerry P. Keilsohn, James J. Leary, and Frank A. Palocsay. Dept. of Chemistry, James Madison University, Harrisonburg, Va. 22807

Two CADAL programs, giving general chemistry students practice in predicting the products and direction of simple inorganic reactions, are described. These augment a lecture-laboratory assignment presently in use at James Madison University.¹ The first program requires that the student predict the products and direction of a series of randomly generated reactions. This program makes corrections in student generated results and offers aid. The second program repeats the process for oxidation, reduction reactions. These programs are written in BASIC and implemented on an OSI C2-8F disk based microcomputer.

¹ Palocsay, Frank A., and Leary, James J., ACS MARM, April, 1977.

BACTERIAL MEMBRANE ELECTRODE FOR THE DETERMINATION OF NITRATE. R. K. Koles, D. J. Rice*, and D. S. Floumoy*. Dept. of Chemistry, Virginia Commonwealth Univ., Richmond, Va. 23284

A novel potentiometric sensor has been developed for nitrate by coupling the bacterium *Azotobacter vinelandii* with an ammonia gas-sensing electrode. Nitrate is reduced to ammonia by a two step process involving the enzymes nitrate and nitrite reductases contained in the bacterial cells. The ammonia produced is detected by the gas-sensing electrode. The response of the resulting bacterial sensor is linear over the concentration range of 1×10^{-5} to 8×10^{-4} M with a slope of 50 mV/decade. There was no indication of deterioration of this response after a period of two weeks when the electrode was stored in the growth medium. Selectivity studies were performed by testing the response of the electrode to inorganic ions and organic nitrogen-containing compounds. Nitrate containing samples were analyzed with an accuracy and precision between 3 to 4%. The advantages of using intact bacterial cells to mediate a multi-step enzymatic process requiring cofactors are clearly demonstrated. (Aided by grants from Research Corporation and Virginia Commonwealth University Grants-In-Aid for Faculty)

CHEMISTRY RESEARCH IN AN INDUSTRIAL ENVIRONMENT. George P. Koch*, Metallurgical Research Division, Reynolds Metals Company, Richmond, VA 23229

Research in an industrial environment may be described as a search for solutions. The fields of chemistry that are applied in the operations of a large primary metals producer are discussed in terms of research in those fields and particular problems requiring a competence in those areas.

THE CHANGING ENVIRONMENT OF PHARMACEUTICAL RESEARCH. Carl D. Lunsford. A. H. Robins Company, Inc., Richmond, Va. 23220

Many factors are bringing change to the methods of chemical and related scientific research in the pharmaceutical industry. These include increased government regulations, improvement in instrumentation capability and sensitivity, expanding knowledge of the biochemical basis for disease, and the general advancement of the sciences.

Resulting negative trends are rapidly increasing costs, longer time cycles for new drug introduction, unavailability of certain products to the public, and the relocation of research efforts. On the positive side, the quality and documentation of industrial research, and hence the credibility, are improving. There is a safer laboratory environment. Increased emphasis on short term project and target oriented research are resulting in the development of therapeutically significant new drugs.

These factors are discussed from the view of research management of a moderate size pharmaceutical company.

STIMULATED CHRONOAMPEROMETRY - AN EXPERIMENT IN COMPUTER GRAPHICS. J. C. Mason and H. M. Bell, Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

An simulated experiment has been developed for use in the undergraduate laboratory to demonstrate the technique of chronoamperometry. The experiment includes 1) Concentration-time profiles for diffusion, 2) Concentration-distance profiles, 3) "Wiring" the apparatus and setting the parameters to yield representative current time curves which can be measured and hard copied. The final step involves hand calculation of the data.

MODIFICATION OF DRUGS, DRUG PRECURSORS, AND NATURAL PRODUCTS WITH PENTAFLUOROSULFANYL ISOCYANATE. J. F. Matt* and A. F. Clifford. Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The introduction of fluorine or fluorinated groups into pharmaceutical products has resulted in modification of the compounds' biological activity. For example, 5-fluorouracil is an effective antitumor agent, whereas, uracil itself has no such effect. We have found that the pentafluorosulfanyl group can be introduced into a variety of drugs and drug precursors by the reaction of pentafluorosulfanyl isocyanate with hydroxyl, amino, or carboxylate functionalities.

THE ANALYTICAL PROBLEMS OF POTTERY ANALYSIS William H. Matthei, Jr. and Michael A. Pleva, Dept. of Chemistry, Washington and Lee University, Lexington, Virginia 24450.

Several methods of qualitative analysis of both pottery and glazes were investigated. Emission spectroscopic, polarographic, and differential pulse stripping voltametric methods will be discussed and compared. Work is now continuing in the area of quantitative analysis by the differential pulse stripping method. Progress and problems to date and further possibilities and plans will also be mentioned.

THE PREPARATION OF SOME INTERESTING RUTHENIUM(II) COMPLEXES. Daniel J. Nardi, Stephen A. Hackney, and Frank A. Falocsay. Dept. of Chemistry, James Madison University, Harrisonburg, Va. 22807

A series of Ruthenium (II) complexes of the general formula RuB_2L_2 ($B=2,2'$ -bipyridyl, $L=H_2O, Cl$, or an aromatic amine) have been synthesized using two different routes.¹⁻³ Two isomers of each complex have been isolated. Spectral interpretation and electrochemical studies of the reaction products leads us to propose cis and trans geometries for the isomer pairs.

DEVELOPMENT OF NEW OR IMPROVED PROCESSES FOR SYNTHETIC FIBERS. J. H. Newland and R. A. Lofquist. Fibers Division, Technical Center, Allied Chemical Company, Petersburg, Virginia.

The growth rate in production and consumption of synthetic fibers throughout the world continues to be the fastest of all chemical products. The continuing effect of this growth to meet the needs and wants of the public and to meet competition between fiber producers is both process and product obsolescence.

The future position of the textile industry will depend on synthetic fiber expansion via economical processes and introduction of new products. Therefore effort continues to be aimed at process and product improvements. Since new equipment is required for process modification the future of the fiber production machine industry is tightly interwoven with that of the fiber producer. This presentation will describe briefly the development of new or improved processes and products for apparel, home furnishing and industrial yarns. These advances allow the synthetic fiber producer to continue to expand rapidly despite rising energy and labor costs.

¹ Krause, R. A., "Synthesis of Mixed Complexes of Ruthenium(II) with 2,2'-bipyridyl," *Inorganica Chimica Acta*, 22 (1977) 209-213.

² Johnson, E. C., Ph.D. Thesis, U.N.C. Chapel Hill, 1975.

³ Meyer, T. J., et al, unpublished results.

CYCLIC QUATERNARY AMMONIUM POLYMERS. Raphael M. Ottenbrite and William Ryan, Dept. of Chemistry, Va. Commonwealth Univ. Richmond, VA 23284

As part of our study involving the synthesis of anionic and cationic polyelectrolytes we have developed a new cationic polyelectrolytic system by the 1,3-polymerization of *N,N*-dimethyl-2,3-dimethylenepyrrrolidinium bromide. This polymer has a five-membered pyrrolinium ring in the backbone of the polymer chain.

The first polymer obtained from this system exhibited intrinsic viscosities of only 0.8-1 dl/g. Performance evaluation of this polymer was made by comparing it to commercial Cat-Floc on a 50 ppm montmorillonite clay suspension using the method of Black and Vilaret. Samples of our polymer in the test had intrinsic viscosities of less than 1 dl/g, while that of the Cat-Floc was 1.2 dl/g. Floc times and residual turbidities, though not as good, were comparable to Cat-Floc. Buchner funnel tests to determine activated sludge dewatering performance were made with better results than with Cat-Floc.

Since these tests, we have greatly increased the molecular weight of our *N,N*-dimethylpyrrolidinium bromide polyelectrolyte to as high as 4.0 dl/g. We have also determined the effect of additives such as salts, oxygen, initiators, concentration and inhibitors. It is apparent from these studies that this polymer greatly exceeds the molecular weight obtained by any other cationic polymer system and that its potential utility should be commensurate. We have also conducted studies to elucidate the cyclic structure of Cat-Floc.

THE ESSENTIAL ARGININE RESIDUE IN THE ACTIVE SITE OF CHICKEN MUSCLE PYRUVATE KINASE. Evelyn A. Pratt* and James H. Yuan, Dept. of Chem. Sciences, Old Dominion University, Norfolk, VA 23508.

Pyruvate kinase purified from chicken breast muscle is inactivated by incubation with 2,3-butanedione in 50mM MOPS-borate buffer (pH 7.5) and 25%. The rate of inactivation is linearly dependent upon the concentration of 2,3-butanedione with a second-order rate constant of 0.015 M⁻¹ min⁻¹. Very little activity is lost when modification is performed in the presence of phosphoenolpyruvate. Protection against 2,3-butanedione inactivation is also provided by Mn-ADP and Mg-ADP. The interaction of 2,3-butanedione with arginyl residue in the active site of several pyridine nucleotide and adenine nucleotide dependent enzymes has been reported. The data obtained in these studies suggest that an arginyl residue plays an essential role in the enzymatic mechanism of pyruvate kinase. The details of arginyl residue modification and the inactivation of pyruvate kinase will be presented.

MULTIPLE METHODS FOR THE ANALYSIS OF 2'-O-METHYLATION IN 5.8S rRNA. S. G. Ryan* and T. O. Sitz, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA 23508.

The 5.8S rRNA molecule contains two ribose methylated positions. One of the methylated nucleotides, a uridine residue at position #14, is a partial methylation. In tumor cells the uridine residue is 20% methylated compared to 70% in normal tissue. In the sequence analysis of the 5.8S rRNA molecule a pancreatic digest was followed by separation of the fragments on a two-dimensional Sanger map. Although this is a reproducible method for determination of the level of methylation of the uridine residue the procedure is too tedious and time-consuming to use for the analysis of many samples. We are currently comparing several methods which will allow us to run several samples simultaneously and get reproducible results. These methods include a two-dimensional cellulose tlc separation of digested nucleotides (Biochem. 14, 1956), one-dimensional paper electrophoresis on DEAE in 7% formic acid, one-dimensional paper electrophoresis on Whatman 3mm at pH 3.5, and one-dimensional paper electrophoresis on DEAE at pH 3.5. The results of these comparisons will be reported.

GETTING MORE THAN MOLECULAR GEOMETRIES FROM X-RAY DIFFRACTION. Wayne H. Pearson* and Fred K. Ross, Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

X-ray diffraction techniques have long provided a means to determine molecular geometries in the solid state. In addition to the location of atomic positions, information is contained in the x-ray intensities concerning the electron densities and, therefore, the electronic charges on atoms in a compound. Unfortunately, this information cannot be obtained directly from the intensities since relative phase relationships are lost in the measurement. As a result, it is necessary to refine a model which approximates the electron distribution.

The discussion will emphasize the spherical atom approximations for modeling electron distributions about atoms and computing local ionic charges. In addition, the x-ray minus neutron method for constraining x-ray refinements and qualitatively displaying valence electron distributions will be described.

NEW HETEROCYCLIC SEMICARBAZONE AND THIOSEMICARBAZONE ANTITUMOR AGENTS. Adriene Y. Principe*, R.L. Williams, Dept. of Chemical Sciences and L. Wolfenbarger, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, VA 23508.

A number of α-(N)-heterocyclic formylthiosemicarbazones have been synthesized and evaluated for antitumor(AT) activity in a variety of transplanted animal tumor systems. One of the earliest and most effective AT agents in this class of compounds was the 2-formylpyridine thiosemicarbazone. The generally accepted mechanism of action suggests that this class of compounds primarily blocks DNA synthesis in tumor cells by inhibiting the enzyme ribonucleotide reductase. This results either by chelation of the compound with the enzyme dependent ferrous ion or through the involvement of a preformed metal chelate which inhibits reductase activity.

Due to the reported toxicity of many of the compounds examined thus far, we have extended the search for effective AT agents in this class to the semicarbazone and the thiosemicarbazone derivatives of the di-2-pyridyl ketone and the 1,8-diazafluorenone ring systems.

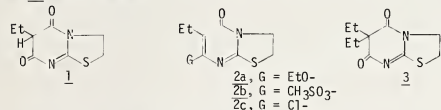
The discussion will include the synthesis and characterization of these compounds and their quaternary salts, as well as preliminary data which suggests potential AT activity against Ehrlich ascites tumor cells in mice. The potential activity was determined by the *in vitro* incubation of the agents with tumor cells and subsequent monitoring of weight change in mice after injection of the treated cells.

FURTHER STUDIES ON THE HENITZESCU SYNTHESIS OF 5-HYDROXY-INDOLES. Elizabeth K. Saunders* and James B. Patrick, John Baker Daffin Laboratory of Chemistry, Mary Baldwin College, Staunton, Virginia 24401.

We have previously reported that the Henitzescu synthesis of 5-hydroxyindoles can often be effected most conveniently at room temperature in nitromethane as a solvent. In these reactions, the use of methyl β-amino crotonates instead of the more commonly used ethyl esters leads to dramatic improvements in yields, often exceeding 90%. A bimolecular face-to-face electron transfer complex was postulated as the critical intermediate in the Henitzescu reaction to account for these findings. We now report new work which extends and amplifies the earlier observations.

ALKYLATION STUDIES ON 6-ETHYL-2,3-DIHYDROTHIAZOLO [3,2-a] PYRIMIDIN-5,7-DIONES. Ernst M. Schubert, R. G. Bass, Department of Chemistry, and Richard M. Glennon, Department of Pharmaceutical Chemistry, Va. Commonwealth Univ., Richmond, Va., 23284

The title compound 1 undergoes alkylation with ethyl iodide or ethyl sulfate at the 7-position yielding the 0-ethylated product 2a rather than 6,6-diethyl product 3 as reported previously. Reaction of 1 with mesyl chloride gives 2b which on reaction with K_2CO_3 in absolute ethanol also gives 2a. Treatment of 1 with $POCl_3$ gives 2c which on reaction with K_2CO_3 or $NaOEt$ in ethanol produced a mixture from which no 2a was isolated.



Authentic 3 was prepared by the reaction of 2-aminothiazoline with diethyl ethymalonyl chloride in THF containing triethylamine or by the reaction of 5,5-diethyl-2-thiouracil with excess 1,2-dibromoethane. This work was supported in part by NIH Grant #9815-3409.

MAGNETIC CIRCULAR DICHROISM OF HYPERSENSITIVE BANDS OF Nd (III) AND Er(III). J. Scrivenner and D. D. Shillady, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, VA 23284

The hypersensitive transitions of $Nd(III)({}^4G_{5/2} \rightarrow {}^4I_{9/2}$ at 578nm) and $Er(III)({}^2H_{11/2} \rightarrow {}^4I_{15/2}$ at 521nm and ${}^4I_{15/2}$ at 379nm) have been studied by magnetic circular dichroism for the chlorides, acetylacetonates (AcAc) and ethylenediaminetetracetates (EDTA). In contrast to minor changes in the absorbance spectra, these bands show enormous changes upon ligand substitution. The 578nm $Nd(III)$ band and 521nm $Er(III)$ band are sufficiently detailed and sensitive to ligand environment that simple fingerprinting of ligands is possible.

THE RATE OF QUENCHING OF SINGLET EXCITED STATE OXYGEN BY IODINE. F. E. Scully, Jr., Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA 23508.

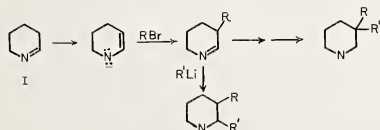
We have previously noted that iodine reacts with potassium superoxide in dry benzene to form singlet excited state oxygen which can be trapped with diphenylisobenzofuran. Less reactive trapping agents are unable to intercept the singlet oxygen formed. It appears that iodine, which oxidizes the superoxide to singlet oxygen, quenches the singlet oxygen it helps to form. We have confirmed this with studies on the quenching by iodine of the reactions of singlet oxygen with triphenyloxazole and with tetracycline. Methods and problems of estimating the rate of quenching from this data will be discussed. Determination of the quenching constant by changes in the fluorescence intensity of diphenylisobenzofuran has been made and will be compared with estimates. The significance of this data on the ability of iodine to photosensitize the formation of singlet oxygen will be discussed.

THE DISCOVERY OF A NEW CLASS OF RIBOSE METHYLATION IN RIBOSOMAL RNA. T. O. Sitz, Chem. Sci. Dept., Old Dominion Univ., Norfolk, VA 23508; K. D. Somers, Microbiol. Dept., E.V.M.S., Norfolk, VA 23501; R. N. Nazar*, R. N. Bot. and Genetics Dept., Univ. of Guelph, Guelph, Ontario (CANADA).

The mammalian 5.8S rRNA contains two 2'-O-ribose methylated positions in its sequence. Position 14 contains a partially modified uridine (UmG) which was found to vary from 0.15 to 0.85 molar amounts in a variety of tissues with the lowest yields in cancer cells. The other methylation is found in a guanosine at position 77 (GmC) which remains completely modified in all tissues examined. Earlier results had shown that this GmC position was completely modified in the 45S precursor in the nucleus. However, recent results have shown that the UmG position that is hypomethylated in cancer cells is modified in the cytoplasm. This modification in position 14 also affects the hydrodynamic shape allowing for a more open conformation. This cytoplasmic modification may play an important role in controlling the function of this RNA in protein synthesis.

THE REGIOSELECTIVE 3-ALKYLATION OF PIPERIDINE VIA THE CYCLIC ENAMIDE. R. D. Todd* and F. E. Scully, Jr., Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA 23508.

Δ^1 -Piperidine (I) is an unstable imine which possesses unusual reactivity. Recently, we reported that alkylolithium reagents can add to the imine carbon, but that Grignard reagents cannot. We now wish to report that Grignard reagents generate enamide anions by abstraction of a proton α to the imine carbon. Alkylation of the 3-position of the piperidine ring can be accomplished by addition of an alkyl halide. We have used this technique in conjunction with either alkylolithiation or lithium aluminum hydride reduction to generate 3,3-dialkyl- or 2,3-dialkylpiperidines. Conditions and limitations of the reaction will be discussed.



RATES OF PRODUCTION OF SINGLET AND TRIPLET METHYLENE FROM

THERMOLYSIS OF KETENE. Carl Trindle and Nevzat Aktekin, Dept. of Chemistry, Univ. of VA, Charlottesville, VA, 22901, and Teorik Kimya Bolumu, Orta Dogu Teknik Universitesi, Ankara, Turkiye

The detailed potential surfaces for the thermally-induced dissociation of ketene to carbon monoxide and singlet and triplet methylene are generated by MINDO/3 computation. An analytical expression is fit to the computed surfaces, and used to estimate the relative rate of production of singlet and triplet methylene. Both statistical and Morte Carlotrojectory studies are employed to estimate rates. The central question addressed in this work is whether it is more probable that spin is conserved in the initial dissociation and that the triplet methylene is formed after many subsequent collisions; or whether the more stable triplet methylene can be produced during the initial dissociation. If the latter is possible, a re-interpretation will be required of the data on which Skell's rules for singlet-triplet methylene reactivity are based.

A CONVENIENT AND RAPID QUALITATIVE TEST FOR ACETAMINOPHEN IN URINE. Janine F. Trigg*, Karl F. Menk*, and James B. Patrick, John Baker Daffin Lab. of Chemistry, Mary Baldwin Coll., Staunton, Va. 24401 and Lab. of Pathology, King's Daughters' Hosp., Staunton, Va. 24401

Numerous reports from Great Britain and Europe describe serious, often fatal, effects from overdoses of acetaminophen. As use of this drug increases in the U.S. there is need for a simple and rapid method for detection of acetaminophen in urine, particularly because promptness is crucial in initiating treatment for overdose. We have developed a test for emergency room use involving thin-layer chromatography of a urine extract and visualization of the acetaminophen spot by a color test with diphenylpicrylhydrazyl, a stable free radical. The test can be run in duplicate in 15 minutes, is highly specific for acetaminophen, and will detect levels as low as 4 ppm. The normal therapeutic dose of acetaminophen is detectable up to nine hours after ingestion. Tetracycline interferes by giving a false positive, but can be easily differentiated by its fluorescence under ultraviolet illumination. The reliability of the test has been checked by a double blind procedure on 36 specimens.

NMR Studies of the Monovalent Cation Site in Pyruvate Kinase. Jeanne M. VanDivender and Charles M. Grisham, Department of Chemistry, University of Virginia, Charlottesville, Virginia.

The monovalent cation site of rabbit muscle pyruvate kinase has been examined in a series of lithium-7 NMR studies. Interactions between enzyme-bound Li^+ and substitution-inert, paramagnetic CrATP at the ATP site of the enzyme have been used to determine $\text{Li}^+-\text{Cr}^{3+}$ distances at the active site. Thus the increase in $1/T_1$ for the Li^+ nucleus caused by enzyme-bound CrATP in the absence of substrates is consistent with a $\text{Li}^+-\text{Cr}^{3+}$ distance of 4.9 \AA . Binding of pyruvate has no effect on this distance. Mg^{2+} , which can bind to a divalent cation site distinct from the CrATP site, increases the $\text{Li}^+-\text{Cr}^{3+}$ distance to 6.0 \AA , both in the presence and absence of pyruvate.

These distances can be combined with 15 other distances obtained from paramagnetic relaxation studies on this enzyme to yield a model of the conformations and arrangement of bound substrates and activators on pyruvate kinase.

MICROCOMPUTER-AIDED POLAROGRAPHIC ANALYSIS. John S. White, Mark F. Cheek, and Frank A. Settle, Jr., Dept. of Chemistry, Virginia Military Institute, Lexington, VA 24450.

A project involving interfacing a small Intel 8080 microcomputer system (E and L Instruments, Inc., Mini Micro Designer) to a Princeton Applied Electronics Model 174A Polarograph is described. A Keithley Model 160 digital voltmeter is used to convert analog data from the polarograph to digital data which is then latched onto the computer input bus. The computer system collects and stores data from routine differential pulse polarographic scans, identifies sample components by comparison to previously stored peak potentials, and performs quantitative analysis on each component using stored calibration data. A Lear Siegler Adam-3A video terminal is used to input parameters required for the analysis of data and to output results. The design of both hardware and software components of the system are outlined and the results of typical analyses are presented.

NEW ACETYLCHOLINESTERASE REACTIVATORS. R. L. Williams and Andrea Lumsford, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23452

The search for new reactivators of phosphorylated acetylcholinesterase has intensified over the past years due to the introduction of a variety of potent enzyme inhibitors in the form of organophosphorus pesticides (PF) and nerve gases. The general mechanism of such inhibition can be shown as:



Reactivation of the inhibited acetylcholinesterase (AChE-P) has been demonstrated with only a very limited number of organic compounds, the best of these being 2-PAM, a heterocyclic oxime.

We wish to report the synthesis, characterization, and preliminary activity data of a series of bipyrilidyl and 1,8-diafluorenone derivatives which appear to have reactivation potential for acetylcholinesterase, and which are currently being evaluated for reactivation activity.

MORE ON COMPUTERS IN CHEMISTRY. John H. Wise, Dept. of Chemistry, Washington and Lee University, Lexington, Virginia 24450

A new time-sharing computing system has been installed at Washington and Lee. On this system, programs which formerly were entered from paper tape are now disc resident and accessed on CRT terminals. The department maintains a dial-up terminal, and a number of hard-wired terminals are available on campus for essentially twenty-four hour use. The department continues to offer instruction on the use of the terminals and on elementary BASIC programming, with some problem assignments. Many of the former programs have been modified and adapted to the new system, and many new programs have been developed for optional use by students. A graphics display terminal will shortly be available for additional applications.

Experiences with the new system and descriptions of some of the recently developed programs will be presented. Of special interest are programs in kinetics and in qualitative analysis.

PURIFICATION AND CHARACTERIZATION OF MOLECULAR COMPONENTS INVOLVED IN THE INTESTINAL ABSORPTION OF IRON. James H. Woodruff* and Richard W. Topham, Department of Chemistry, University of Richmond, Virginia 23173.

An enzyme system capable of promoting the incorporation of iron into transferrin has been isolated from rabbit intestinal mucosa. Ultrafiltration studies indicate that the intestinal enzyme system is composed of a heat-labile protein and a small, heat-stable cofactor. The protein component and cofactor can be separated by gel-filtration and further purified by additional gel-filtration and ion-exchange chromatography. The ultraviolet spectrum, fluorescence spectrum, and mobility on TLC of the purified cofactor are identical to those of xanthine. Furthermore, authentic xanthine can be substituted for cofactor and cofactor preparations will serve as substrate for xanthine oxidase. The purified intestinal enzyme differs structurally and kinetically from ceruloplasmin and xanthine oxidase. By promoting the incorporation of iron into transferrin, this intestinal enzyme could serve a similar function in iron absorption as ceruloplasmin serves in iron mobilization. (Supported by USPHS, NIH Grant 1R01 AM 201-48-01; a grant-in-aid from Research Corporation, and faculty and undergraduate grants from the University of Richmond.)

Education

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

A COLLEGE COURSE: ENERGY: PERSPECTIVES AND CONSUMER SERVICE. C. James Bier Dept. of Chemistry Ferrum College Ferrum, Virginia 24098

This paper presents the experience with and design of a course which treats energy supply and use on international, national, and local levels. Emphasis is on practical evaluation of energy use in specific consumer situations with the goal of saving money for the consumer and energy for our posterity. The course objective is to prepare the student to perform energy analyses for individuals and small businesses emphasizing the built environment and to make and explain recommendations for improving energy conservation and efficiency. The student is also given the background to explain the recommended conservation measures in terms of the greater social and economic context. The course includes a laboratory - field experience component.

DESIGNING A FACULTY MERIT PAY SYSTEM: THE IMPERATIVE PRELIMINARIES. J.P.B. O'Brien, Dept. of Psychology, and D. M. DiCroce*, Dept. of English, Tidewater Community College, Virginia Beach, VA 23456

Before the costly investment of time, talent, research, development, and marketing, a merit pay system initiative requires some difficult preliminary work. Answers to the following questions will determine the quality and viability of the approach or whether or not the issue should be seriously approached at all: (1) Why have merit pay? (2) How will merit pay be funded? (3) Who is the prime mover of a merit pay concept? And why? (4) Who of the administration is committed to, or likely to become committed to, a merit pay concept? And how sincere is this commitment? (5) How should the degree of commitment affect a construction of a ranking system for merit pay? (6) What harsh realities demand recognition when attempting to build upon existing evaluation methods or initiate new methods? (7) What predictions can be made about the degree of sincere faculty commitment to a merit pay/evaluation system? How will such predictions affect development and/or implementation of the entire system? (8) Can the system be simulated before it is actually implemented? (9) Will the system be static or evolving? (10) Are there effective mechanisms for system evaluation by the evaluatees and the evaluator? The answers to these questions should indicate the scope and permit the initiation of an appropriate design.

DEVELOPING GOALS AND OBJECTIVES FOR THE MIDDLE SCHOOL SCIENCE PROGRAM J. D. Exline, Dept. of Education, P.O. Box 6 Q, Richmond, VA 23216

Due to concerns expressed about the intermediate/junior high school science programs, the Science Service of the VA Dept. of Education is developing goals and objectives for a middle school science program. These goals and objectives, directed towards grades six, seven, and eight, are the foundation and the beginning of a comprehensive statewide effort aimed at addressing the expressed concern. Also the middle school science program is the initial step in providing better articulation of a K-12 science program under the umbrella of the Standards of Quality, NSTA Guidelines for Science Education, and the Science Service Five Year Plan.

Focusing upon the research concerning the characteristics of the adolescent child, a statewide middle school committee has spent the past several months developing goals and objectives which it feels will better address the science education needs of this age group of students. The reaffirmation of the need for more and better types of laboratory experiences, the need to develop content around behavioral and conceptual themes, and the need to make the content of science more relevant for this age group by providing knowledge of its application to energy-environmental concerns are part of the committee's recommendation.

Public presentation of the first draft is being used to get suggestions for the final revision. This draft will be modified by the middle school committee on the basis of feedback suggestions and comments.

LIQUID-LIQUID ION EXCHANGE--A DEMONSTRATION FOR THE CLASSROOM. E. M. Heirfield. Mary Baldwin Col., Staunton, Va. 21401

The selective recovery, purification, and concentration of copper values from leach liquors with liquid ion exchangers has received broad interest throughout the copper industry. This paper discusses the chemistry of these processes and presents a classroom demonstration and "research style" activities for better students. Inclusion of this material in general chemistry or physical chemistry classes would greatly enhance the students' understanding of industrial applications of equilibrium principles and of the relationship of technology to science.

THE AVAILABILITY AND USE OF SCIENCE PUBLICATIONS BY VIRGINIA SECONDARY SCIENCE TEACHERS. Franklin D. Kizer, Virginia Supervisor of Science, Retired, Route 2, Box 637, Lancaster, Virginia 22503.

A random sample of Secondary Science Teachers in the Virginia public schools was taken in 1975 to determine what science publications were available and which were considered most effective in assisting teachers to keep updated with scientific knowledge and classroom techniques. THE SCIENCE TEACHER AND THE AMERICAN BIOLOGY TEACHER were reported as being the most useful. THE VIRGINIA JOURNAL OF SCIENCE was only reported by one teacher.

The Education Section is challenged to contribute to making THE VIRGINIA JOURNAL OF SCIENCE a more useful publication to our Virginia Secondary Science Teachers.

OVERCOMING MATHEMATICS ANXIETY, Leatrice A. Kaplan and Betsy H. Little, John Tyler Cmty. Col., Chester, Va. 23831.

Recently there has been much interest in the understanding and treatment of mathematics anxiety. The purpose of this paper is to discuss some of the causes of mathematics anxiety and to suggest some techniques for coping with the fear and avoidance of mathematics.

As with other stressful occurrences, the fear of mathematics is basically a feeling of not being in control of the problem or situation. The language and symbolism are mystifying. The procedures and rules appear inconsistent. There is a general belief that one needs a mathematical mind to solve word problems. These things and more are the sources of mathematics anxiety.

In modern society, it is inescapable that mathematics has become essential in the communication of information. The mathematically disabled person will become increasingly disadvantaged as a citizen and in choosing a career. Thus, it is important to deal with the feelings of mathematics anxiety in order to aid the learning or relearning of basic skills. Some suggestions for coping with anxiety are group desensitization workshops, taking basic level courses, and training by doing puzzles and various mathematical exercises every day. Through understanding and management, the fear of mathematics can be overcome to a point that the individual can get over the barrier of not being able to do the next math problem.

PROBLEM SOLVING STRATEGIES OF SIXTH GRADE STUDENTS WHO ARE SUPERIOR PROBLEM SOLVERS. A. MANDELL, Dept. of Curriculum and Instruction, Old Dominion Univ. Norfolk, Va. 23508.

A sample of 25 sixth grade level students who had been identified as superior problem solvers were administered six problems to solve during an audio-taped interview/problem solving session. The problems selected required a variety of problem solving behaviors and strategies. Type-written scripts were made from each subject's tape and the responses made by the student in solving each problem were categorized according to a predesigned Problem Solving Behaviors classification scheme. The time for completion of each problem and an Efficiency Index (EI) (the number of statements per second) were determined for each student on each problem.

Spearman rho correlation values were determined for each set of students who successfully solved each problem - EI versus percentage use of each of 11 problem solving behaviors. The resulting coefficients were used to define the most effective problem solving strategy employed by the set of students who successfully solved each problem.

The students who successfully solved the set of problems showed evidence of formal thinking patterns, as described by Piaget.

INVESTIGATION OF HIGH PRIORITY COMPETENCIES FROM INSTRUCTION IN ANY SECONDARY SCHOOL SCIENCE. A. Mandell, Dept. of Curriculum and Instruction, Old Dominion Univ. Norfolk, Va.

A comparison of the priority rankings assigned by two samples; (1) the Virginia Science Supervisors Association membership (2) 250 randomly selected secondary school science teachers from Virginia high schools, to a list of possible competencies to be expected of students who have taken any secondary school science, was made.

Mean priority rankings and standard deviations for each of the listed competencies in five categories were determined for each sample. Spearman rho correlation coefficients between the priority rankings of each sample were made in each category.

Rho values of +0.945 for General Competencies, +0.74 for Specific Competencies, +0.73 for Subject Area Competencies, +0.67 for Values Competencies, and +0.54 for Attitude Competencies were obtained, showing good agreement between the two samples on the priorities of secondary school science instruction.

The following were the competencies that received highest consensus priorities. Learning to use rational thought processes. Learning how to attack new problems. Decision making processes. Reading for understanding. Drawing conclusions. Being open-minded. Requiring sufficient data for decision making. Respecting the rights and property of other individuals. Conservation. Ecology. Human Anatomy.

EXPERIENCE WITH AN INTENSIVE PRACTICE-ORIENTED SCIENCE PROGRAM FOR COLLEGE-BOUND HIGH SCHOOL JUNIORS & SENIORS. James B. Patrick, Mary Baldwin College, Staunton, Va. 21401

Since 1977 Mary Baldwin College has operated a special summer science program for college-bound high school juniors and seniors (S.P.). The format of S.P. is intended to utilize the experience that Mary Baldwin faculty have gained in the presentation of high-intensity "total immersion" instruction during the years that the Governor's School for the Gifted has been taught at the college.

Some conclusions on the effectiveness of this type of instruction with students who are not specifically designated as "gifted" will be presented. A second feature of S.P. is its stress on concrete, tangible skills as an essential feature of realistic science instruction; a corollary of that feature is close student-teacher contact and use of a realistic environment - well equipped laboratories and modern instrumentation which the student actually uses. A third feature is an effort to prevent such a program from becoming mere technician training by use of a series of humanistic programs centered around the Erwin Schrödinger "Ascent of Man" film series. Some comments and cautions about the use of this film series are offered. Finally, some tentative conclusions will be offered about the strengths and weaknesses of innovative programs like S.P.

GOVERNOR'S SCHOOL CHEMISTRY - 1978 VERSION. C. L. Stanitski, Dept. of Chemistry, Randolph-Macon College, Ashland, Va. 23005

The Governor's Program For The Gifted (GPFG) selects high-ability, rising seniors from Virginia's secondary schools. This presentation describes the chemistry program offered at the Mary Baldwin campus GPFG center during the Summer of 1978.

As an educator faced with the exciting prospect of interacting with a group of academically select students, a logical question which arises is - what should, can, must, dare (choose the proper verb) I select for our discussion/presentation? The rationale for those topics included in the final version will be described.

After a brief overview of stoichiometry and concentration expressions, the broad area of chemical kinetics was studied, including its application to biological and nonbiological systems. During the latter part of the program, molecular structure and bonding were discussed. Lecture demonstrations and student laboratory investigations in kinetics and chemical structure were performed. Two of the lab investigations will be described in detail.

MATHEMATICS EDUCATION IN AUSTRALIA. H. W. Straley.
Mathematics Dept., Woodberry Forest Sch., Woodberry Forest,
Va. 22989, and Newington Col., Stanmore, NSW, 2048,
Australia

A teacher's perception of his own country's educational system is illuminated by actually teaching in another country. This slide-discussion, comparing mathematics education in Australia and the United States, is based on the author's first-hand experiences as an exchange teacher in an Australian high school. The author visited and lectured in Australian schools and universities, attended conferences, and observed the grading of the Higher School Certificate Examinations (College Entrance Examinations). This talk focuses on "outback" one-teacher schools, elementary, secondary, and college programs, texts, teacher training, and competency examinations.

Engineering

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

THE HIGH-SPEED CENTRIFUGE AS A MEANS FOR SEPARATING SUB-MICRON PARTICLES FROM STACK GASES. R. J. Babarsky* and S. S. Fisher, School of Engineering and Applied Science, University of Virginia, Charlottesville, Va. 22901.

The use of a high-speed, high-throughput centrifuge for separating submicron fly-ash particles from stack gases exhausted by coal-fired power plants is considered. The design of such a centrifuge is reviewed, important considerations in its design are discussed, and its potential performance relative to other devices used for this purpose is considered. Apparatus for some planned proof-of-principle tests is also described.

HAMPTON ROADS 208 PLAN. Paul E. Fisher*, Hampton Roads Water Quality Agency.

The HRWQA, a consortium of the SVPDC, PPDC and HRSID, was established in 1974 to be the designated 208 planning agency for the Southeastern and Peninsula area of Virginia. The Agency applied for and received a \$2.5 million EPA grant to develop a water quality management plan for an area encompassing fourteen cities and counties and ten major rivers and estuaries. The planning process included the identification of treatment facility needs over a twenty year period for municipal and industrial sources, construction priorities for wastewater treatment works, development of a process to identify and control non-point sources of water pollution, and the development of an institutional/management program for carrying out the plan elements. In developing the plan components, the Agency attempted to build on the prior wastewater treatment planning done by HRSID and the other municipal treatment agencies and focused on significant gaps in the water quality data base. The principal focus of the work, therefore, was in the area of water quality sampling and modeling for the major water bodies, and non-point source sampling and modeling. The plan was completed in late summer 1978, and public hearings were held in October of 1978.

A SOLUTION FOR THE OPTIMAL GAP OF A MONOPOLE ELEMENT MOVING IN A SINUSOIDALLY DISTRIBUTED MAGNETIC FIELD. William P. Harrison, Jr., Div. of Eng'g, Fundamentals, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Coulomb's Law is used to establish the x- and y-component forces acting on a monopole of strength M in an x-y planar space under the influence of one other monopole, of strength M', located on the x-axis. M' is then replaced by a distributed field along the x-axis having the form $M' = M'_{\max} \cos(\pi x/x_p)$, where x_p is the half period (over 180°) of this waveform. Integration over the full x-axis (from $-\infty$ to $+\infty$) yields the total-force components, F_x and F_y , acting at M. Restricting motion of M to x-direction translation only, maximizing the acceleration equation reveals that a vertical air gap of about $0.2x_p$ is the optimum placement for monopole M above the x-axis and will result in maximum x-direction acceleration.

AN ENGINEERING/ECONOMETRIC MODEL OF THE U.S. ALUMINUM

INDUSTRY. W. R. Hibbard, Jr., A. L. Soyster*, and M. A. Kelly*, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

A large scale, time dynamic linear programming model simulating the U.S. aluminum industry has been developed using an engineering representation of the flow of materials from mining through refining, smelting and fabrication with special emphasis on scrap recycling. The aluminum supply model is driven by a set of econometric demands derived from historical data. The model results projecting industry investments and operations from 1977 until 1994 are reported and discussed, particularly as they relate to Mineral Policy.

ION TIME-OF-FLIGHT MEASUREMENTS IN UF₆ FLOWS BY THE LASER-INDUCED-BREAKDOWN METHOD. M. G. Hodgins* and S. S. Fisher, School of Engineering and Applied Science, University of Virginia, Charlottesville, Va. 22901.

A method has been developed by which velocities in UF₆ flows are measured by focusing a high-power, pulsed nitrogen laser within the flow and causing electrical breakdown. Ions are formed in this process, and these ions are then collected by a probe located at a known station downstream. The time delay of the probe signal relative to the laser pulse allows one to deduce the flow speed. This method has been applied to high speed free-jet expansions of UF₆ formed by flowing UF₆ through a small nozzle into a vacuum chamber. For these jets, the high UF₆ flow rate is handled by condensing the jets directly on a liquid-nitrogen-cooled plate. These velocity measurements are interpreted in terms of the relevant fluid mechanics and are compared to similar measurements obtained by other methods.

SOLAR ABSORPTION REFRIGERATION FOR THE CONTROL OF INSECTS IN STORED AGRICULTURAL PRODUCTS. F. A. Lachetta, J. T. Beard, G. C. Allings*, and H. J. Manning*. Dept. of Mech. and Aero. Engrg., Univ. of Va., Charlottesville, Va. 22901, and D. P. Childs* and L. W. Fletcher*. ARS-USDA, Richmond, Va. 23240. This paper presents the results of a study of a proposed new method for insect control in post-harvest stored agricultural products. The method is based on the fact that the larvae of the cigarette beetle are killed and the growth cycle is interrupted if the commodity is maintained at or below 40°F for more than 21 days.

The proposed system would use an annual-cycle solar-driven aqua-ammonia absorption refrigeration system to produce ice for cooling of tobacco storage facilities.

Ice forms on tubes, is produced throughout the year, and is used approximately one month a year to provide environmental cooling of the tobacco storage for insect control. This system offers several advantages over one in which the cooling is produced as needed. The solar collectors and absorption refrigerator can be many times smaller as they are used throughout the year. The storage tank provides a buffer between the variable energy source and the cooling load; the cooling capacity is developed when it is sunny, but the tobacco storage can be cooled at a time when the weather is cold and the cooling load is at a minimum.

Results of a computer simulation written to aid in the design of the system and the analysis of system parameters will be presented.

THE ALARMING PERCENTAGE OF U.S. PATENTS GRANTED TO FOREIGN NATIONALS vs. THE AMERICAN ENGINEER. Howard R. Johnson

Having worked in research for a number of years it was a shock to learn that in many of the 20 top technical categories of U.S. patents that American citizens trailed painfully. The office of Technology Assessment & Forecast gave an early warning report to the Dept. of Commerce in 1973 showing that the following prevailed and that "very shortly" the following would be true:

	1973	"very shortly"
Purification of molten iron	77%	??
Automotive fuel devices	61%	??
Super conductors	72%	90+%
Liquid fuel rockets	31%	65%
Automatic arc-welding	41%	78%

We are now past the "very shortly" time period and the percentages continue to slide. It cannot be forecast just when the last American citizen will file a technical patent, but it can't make much difference when the percentages are as low as they are. Add to this the attitude of the Justice Department where the 9th District Court has never upheld a patent, or the west coast where no patent has been held valid for 20 years, and you have the picture of a foregone reality.

WATER QUALITY TRENDS IN THE NANSEMOND RIVER. Linda R. Kilch. Dept. of Estuarine Processes, Va. Inst. Mar. Sci., Gloucester Point, Va. 23062.

The Nansmond River, a tributary of the James River, has exhibited severe water quality conditions in the past. High fecal coliform levels, low dissolved oxygen concentrations, and excessive nutrient levels have been observed by various researchers in the past thirteen years, especially in the headwater region of the estuary. An overloaded sewage treatment plant and non-point source runoff, coupled with poor flushing in the headwater region of the river has been suggested as the source of water quality problems.

A COMPUTERIZED ENERGY EVALUATION OF SCHOOLS UTILIZING PSECS4 A.C. Prichard*, R.R. Somers, II*, and L.S. Fletcher. Center for Energy Analysis, Dept. of Mech. and Aero. Engrg., Univ. of Va., Charlottesville, Va. 22901

As energy prices continue to rise, many school systems have initiated energy conservation programs in an effort to save money by reducing energy consumption. However, these school systems often require assistance in determining what energy conservation measures are cost effective and in what order the energy saving techniques should be implemented. The Public Schools Energy Conservation Service - Version 4 (PSECS4) computer software package recently has been released by the U.S. Department of Energy (DOE) to help supply the energy management assistance needed by many school systems. The PSECS4 computer program provides recommendations both for changes in the operation of school facilities as well as for capital improvements to the school building envelope and energy systems to reduce energy consumption. PSECS4 also computes the energy and fiscal savings resulting from effective energy conservation measures.

The Center for Energy Analysis at the University of Virginia recently has completed a study of seven Albemarle County school buildings using the PSECS4 software. Results of this study will be used to demonstrate the capability of PSECS4 to point out energy-consuming inefficiencies in school buildings and to approximate the cost of implementing energy conservation techniques.

ENERGY CONSERVATION METHODS FOR PUBLIC SCHOOLS. R.R. Somers, II*, B.C. Chandler*, and L.S. Fletcher. Center for Energy Analysis, Dept. of Mech. and Aero. Engrg., Univ. of Va., Charlottesville, Va. 22901

Increasing fuel costs have compelled many school systems to reexamine their energy-consuming practices as they seek to minimize energy expenditures through reductions in fuel use. It has been estimated that over \$600,000,000 could be saved in school buildings through proper energy management requiring virtually no capital investment. The Center for Energy Analysis at the University of Virginia recently has had the opportunity to conduct energy audits in a number of elementary and secondary schools in central Virginia. During the course of these studies, a number of energy-wasting problems have been observed that are common to a majority of the school facilities that were inspected. Undoubtedly, many of these same problems exist in school buildings throughout the Commonwealth of Virginia. Energy conservation measures that can be used to correct these inefficient uses of energy in schools will be reviewed. Results of computerized studies of the energy use of several schools will be used to indicate the relative magnitudes of the savings that could be realized through efficient energy consumption.

VIRGINIA'S NONPOINT SOURCE CONTROL STRATEGY. E. R. Southerland*, Virginia State Water Control Board, Richmond, Virginia 23230

Section 208 of the 1972 Federal Water Pollution Control Act Amendments requires each state to develop a nonpoint source control strategy. The keystone of the State Water Control Board (SWCB) strategy for Virginia is the development of Handbooks which describe Best Management Practices (BMPs) for reducing or preventing pollution from agriculture, forestry, mining, urban areas, hydrologic modifications, saltwater intrusion, and residual waste disposal. Each BMP Handbook was developed by a Technical Advisory Committee of State and Federal agencies and a Citizens Advisory Committee of special interest groups who have expertise in the land use. All BMPs are considered open to revision as better understanding of nonpoint source controls is gained through field implementation and monitoring of their effectiveness. Because of the lack of data on BMP benefit-costs, the SWCB strongly supports a non-regulatory program for BMP implementation. The voluntary strategy will be outlined in a Management Handbook to be prepared in 1979 by the SWCB and its State Policy Advisory Committee. An assessment will be made statewide to identify nonpoint source problem areas. Public education programs and technical and financial assistance for BMP implementation will be concentrated in the top priority watersheds.

NONPOINT SOURCE STUDIES IN THE OCCOQUAN BASIN. B. L. Weand and T. J. Grizzard*. Civil Engineering Dept., Va. Polytechnic Inst., Blacksburg, Va. 24061

The Occoquan Watershed, which lies on the southwestern periphery of the Washington, D.C. metropolitan area, has an important water supply reservoir at its mouth and a rapidly expanding urban area at an intermediate point upstream. This impoundment, which serves an estimated 600,000 people, has exhibited a rapid decline in water quality during recent years. The severity of this problem prompted the Virginia State Water Control Board to promulgate regulations requiring the consolidation of existing wastewater discharges in the basin and subsequent treatment by a state-of-the-art advanced waste treatment process.

Recent studies, however, have shown nonpoint pollution to be a problem of increasing importance as point source waste discharges are treated to a higher degree or eliminated completely. The Occoquan Watershed Monitoring Laboratory, located in Manassas, Virginia has been intimately involved in research aimed at defining the impact of nonpoint pollution in the Occoquan Basin. The scope of these studies, as well as research currently underway will be discussed.

AN ENGINEER'S DESIGN: PUBLIC PARTICIPATION AND THE PRESS. J.C. Webb and G.R. Webb. Dept. of Physics, Christopher Newport College, Newport News, VA 23606

Despite herculean efforts, engineering firms are frequently unsuccessful in involving citizens in the planning and design stages of large-scale public works and regulations. Citizen input invariably arises after plans have been drawn and preliminary construction has started. Such a situation is undesirable for the citizens, who perceive themselves the victims of an unknown agent, and for the engineer, who is, after all, committed to the public good.

Reliance on the techniques of public relations to ensure the needed participation is the standard practice of these firms. This practice is not adequate. We assert that engineers need to return to those techniques in which they are well-schooled, the analysis of systems, in their design of an approach to public participation.

We present the results of an experiment to increase citizens' awareness of the effect that a water quality study might have on their area, and in turn draw lessons on an alternate mode for reaching the public. The study considered is the 208 waste treatment management plan for Tidewater; citizens are residents of the rural James River county of Isle of Wight. The vehicle for the experiment was the weekly paper for the area, the Smithfield Times. (Aided by NSF Grant #OSS77-23962)

Environmental Science

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

A DETERMINATION OF THE CONCENTRATION OF AROMATIC HYDROCARBONS IN THE WATER AND ZOOPLANKTON OF THE ELIZABETH RIVER, NORFOLK, VIRGINIA. C. W. Banks, Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508

The levels of aromatic hydrocarbons in the water and zooplankton of the Elizabeth River were determined by gas chromatography. Samples of the water from three sites were filtered and extracted using carbon disulfide. Samples of the zooplankton from the three sites were sieved, digested in methanol-KOH in an incubator-shaker, and extracted into carbon disulfide. The extracts were injected into a Varian Aerograph model 1400 gas chromatograph. A disc integrator was used to measure the relative areas under the curves. Standard curves and retention times were used to quantify and identify the compounds. Four compounds, benzene, toluene, xylene, and naphthalene, were identified, with a concentration range of four to 280 ppb for the water, and 50 to 1,180 ppb for the zooplankton.

There was a significant ($r = .05$) correlation of concentrations with site location and depth, and a significant regression of the levels in the zooplankton on the levels in the water. Each compound is accumulated at a different rate in the zooplankton, depending on the aromatic hydrocarbon concentrations in the water and probably on the concentrations in the phytoplankton.

PASSIVE SOLAR ENERGY: FRUGAL BUILDING FOR VIRGINIA'S CLIMATES. C. James Bier, Dept. of Chemistry Ferrum College, Ferrum, Virginia 24088

Passive solar energy means the use of design in arranging building materials, components, surfaces, and spaces to allow the building to best utilize the seasonal and daily path of the sun to provide comfortable interior conditions year round by natural flows of energy. This paper will discuss generic passive solar design concepts with their features and their problems. The paper will also present the author's design innovation Vertical Solar Louvers as they are used in his own home and suggested design applications for Virginia's various climates. Vertical Solar Louvers are a set of massive rectangular columns which are oriented 45° immediately behind south-facing glass. They act as automatic thermal control-storage elements by allowing full penetration of the winter morning sun into the building interior while capturing and storing afternoon solar radiation for night-time use and to prevent overheating of the living space.

A COMPARISON OF AIR QUALITY MEASUREMENTS FOR THE 1977 AND 1978 REGIONAL OZONE STUDY*, G.E. Copeland, Ed Barry and Nehl Aldridge, Dept. of Geophysical Sciences, Old Dominion University, Norfolk, VA 23508.

Regional ozone monitoring experiments were conducted in Eastern Virginia in the summers (1977 & 1978) by ODU, VSACB and NASA. 1978 results at urban and rural sites are presented. Analysis of 1200 hours of data indicates values of NO_x well below the ambient air standards and indicate a source of NO to the NNW of ODU. Total hydrocarbons (THC), methane (CH_4), non-methane hydrocarbon (NMH) and ozone (O_3) were monitored at ODU and Deep Creek Va. THC at Deep Creek averaged 2.5 to 4.0 ppm from N to NNW while at ODU their range was 2.8 to 4.6 with azimuth N and NNW. CH_4 at Deep Creek ranged from 2 to 4 ppm, at ODU CH_4 ranged from 0.2 to 0.4 ppm. NMH at Deep Creek ranged from 0.4 to 0.7 ppm above the standard of 0.24 ppm. At ODU NMH ranged from 1.7 to 3.8 ppm.

Ozone averages at the rural site showed a range of 28 ppb @ ENE (106 hrs) to 70 ppb @ NW (19 hrs). At the urban site the O_3 values ranged from 18 ppb @ NNW (90 hrs) to 36 ppb @ SE (81 hrs). O_3 values during 1978 never exceeded the 120 ppb standard at these sites. O_3 exceeded 80 ppb at Deep Creek 10% and at ODU 8.5% of the time. Evidence indicates transport of high concentrations of O_3 to Tidewater by N, NW and SW winds. These results agree with those found in the 1977 O_3 study. (1)

*Partially funded by NASA-LRC [NAS1-14193-59].

(1) Virginia Academy of Science, 56th Meeting, 1978.

AN INVESTIGATION INTO THE RELATIVE IMPACTS OF VARIOUS ENVIRONMENTAL FACTORS ON BREATHING DIFFICULTY AND EYE IRRITATION AMONG SENSITIVE PEOPLE IN TIDEWATER VIRGINIA - 1978 Joseph W. Crawford, Jr., Hampton Roads Region, State Air Pollution Control Board, Pembroke IV - Suite 409, Virginia Beach, Va. 23462.

This investigation is an attempt to make an assessment, based on purely statistical analyses, of the relative importance of the five Environmental Factors of temperature, humidity, pollen count, fungus count, and photochemical oxidants (ozone) in breathing difficulties and eye irritation experienced by a group of known sensitive people. The investigation was conducted during the months of June through October 1978.

ESTIMATING RELATIVE POTENCY FROM THE HYPERBOLIC DOSE-RESPONSE MODEL.

J. T. Crowe, Jr., A. H. Robins Co., Richmond, VA 23220.

The fundamental dose-response function for many pharmacological and toxic agents can be derived from the assumptions of Receptor Theory and the Law of Mass Action. This function is the rectangular hyperbola, $y = Y_m d / (K + d)$, where y is the response, Y_m the maximum response, d the dose and K is equivalent to the median effective dose (ED50). If two drugs have the same maximum response, an estimator, $R = K_S / K_T$, can be derived which expresses the relative potency of a test drug, T , to a standard, S . This paper presents the derivation and properties of the estimator, R .

THE INPUT OF LEAD AND OTHER METALS TO ECOSYSTEMS BY DRY DEPOSITION. Robert W. Elias, Biology Department, VPI & SU, Blacksburg, VA 24061.

Before 1970, mass balance estimates of ecosystem inputs and outputs generally overlooked inputs by the dry deposition of atmospheric aerosols. Early determinations of dry deposition were made by measuring wet only and wet plus dry deposition in the same type of collector. These measurements, and other similar efforts, are not compatible with the aerodynamic mechanisms of the deposition of aerosols. Recent studies of deposition rates for lead in roadside and remote ecosystems show that these rates are a function of particle size and concentration, plus windspeed and foliar orientation. In this report, natural removal mechanisms, such as rain, were observed by field and SEM measurements, while artificial removal mechanisms (acid-washing) were evaluated as efficient methods of measuring surface deposition on leaves.

The results of these studies show that: 1) artificial collector plates generally overestimate rates of dry deposition by about 25%; 2) laboratory cleaning methods can efficiently remove particles from pine needle surfaces without disturbing interior tissues; 3) lead inputs by dry deposition may represent 40-60% of the total atmospheric input into an ecosystem; and 4) the input of other metals, such as Ca, Sr, Ba, K and Rb, may be as much as 10% of the total atmospheric input.

PHOTON CORRELATION IN LASER DOPPLER SPECTROSCOPY FOR THE DETERMINATION OF PARTICLE SIZE. Aleyamma George*, Dept. of Physics, Norfolk State College, Norfolk, Va. 23504

As the particle moves within the region illuminated by a continuous laser beam, the frequency of the light scattered will be shifted by a very small fraction due to the Doppler effect. The measurement of the shape of this spectrum of frequency shifts is achieved by digital autocorrelation. The photocurrent of the photomultiplier tube (PMT) will give rise to a fluctuation spectrum characterized by the autocorrelation function of the detector output signal. The half width for this spectrum is expressed as $HW = 160 \sqrt{\sin^2 \theta / 2}$ where θ refers to the scattered angle. Thus the particle diffusion coefficient D , and by using the Stokes-Einstein relationships with appropriate slip correction, the particle size can be determined.

In the experiment, the output from the PMT is fed on to a Digital autocorrelator and the analysed data relayed to a minicomputer and processed in real time. This new technique affords precise and rapid measurement of macromolecular diffusion coefficients and particle sizes in hydrosols or aerosols. (Aided by E.P.A. Grant R803765).

WATER QUALITY IN THE HAGUE, NORFOLK, VA., EVIDENCE OF CHANGE. R.E. Johnson. Inst. of Oceanography, Old Dominion Univ., Norfolk, VA. 23508

The Hague is a semicircular tidal basin 2,100 feet in diameter connected at the midpoint of its circumference to the Elizabeth River. It is the bulkheaded remnant of two tidal streams. The Hague was dredged in 1974, deepening the main portion by over four feet. The water quality study performed in summer of 1973, prior to dredging, indicated fecal coliform bacteria counts in excess of 4,500 MPN/100ml average in the Hague. The present study, summer of 1978, indicated MPN counts in excess of 100,000 per 100ml. In addition, both arms of the Hague are now about equal in coliform count. Previously, the Colley Creek arm (westarm) was well below 2,500 MPN/100ml. Tidal surveys indicated that coliform counts were higher at low tide than at high tide and were substantially lower in the Elizabeth River adjacent to the Hague. This implies that the source of the coliform bacteria is within the Hague drainage system.

THE MAX VARIANCE RATIO IN EXPLORATORY DATA ANALYSIS. D. V. MATHUSZ, Ops Res Div of LOGC Ft. Lee, VA. 23501

Exploratory Data Analysis is essentially investigative in nature and as such, its procedures involve graphic displays of the structure of data. Selection of these graphic devices and the data sets are then primary questions for the researcher. To aid in these decisions, a simple index has been devised to measure the amount of clustering at the range extremes or its opposite, i.e. a central cluster whose range is defined by "outliers." This index is the MAX Variance Ratio (MVR). It is the ratio of the variance of the data divided by the maximum variance possible for the same number of data points "n", free to take any values over the same range "R". This MVR has a scale of zero to unity. This unit scale can be divided by a Neutral Variance Ratio (NVR), that defines when the aggregate clustering at the range extremes reverts to the opposite effect. It is shown that the MAX Variance for even n is a $f(R)$ but that for odd n is $f(R,n)$ which asymptotically converges toward $f(R)$ as n increases. It is also shown that in the limit NVR is $1/3$ of $f(R)$. Tables and graphs are provided for small n, not close to the limiting values. The index is demonstrated in a classic example.

SEWAGE EFFECTS IN A SMALL STREAM. R. A. Matthews*, M. Flora*, C. Caupp*, and M. Boucherle*. Ctr. for Environmental Studies, Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

During the winter and early spring of 1978 a study was conducted to evaluate the impact of sewage effluent upon a small stream in southern Indiana. We found the stream to be moderately impacted, sewage effluent representing close to ten percent of the total discharge downstream from the treatment plant outfall. Turbidity, conductivity, ammonia, and soluble reactive phosphorus concentrations increased below the outfall. Dissolved oxygen concentrations demonstrated a typical oxygen sag with recovery. Fish, benthic, and algal diversities were significantly reduced at the site of effluent input; however, both fish and invertebrates recovered downstream.

IMPACT OF IMPOUNDMENT ON DOWNSTREAM FISH AND BENTHIC MACROINVERTEBRATE COMMUNITIES IN A PIEDMONT STREAM. M. Mauney and J. J. Ney. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Impact of a shallow, non-stratifying impoundment on stream biota was assessed through a one-year comparison of upstream and downstream stations. Stream physico-chemical properties were not altered.

Estimated density, biomass, and production of the benthic community were greater in the tailwater than at the upstream or most downstream station and occurred primarily through increase in non-insect groups. Changes in macroinvertebrate composition appeared to be related to differences in food availability. The taxonomic composition of the fish community was similar among stations, but fish biomass was substantially greater in the tailwaters than at the other locations. The fish community in the tailwaters was not stable. Increased fish biomass and instability in the tailwaters may result from upstream movement and reservoir emigration. Transience may be enhanced by competition for food and/or space during some seasons.

The downstream impact of the reservoir was very localized. Benthic and fish communities examined 1200 m below the impoundment were equivalent to upstream levels or were intermediate between those of the upstream and tailwater station.

AN INTERACTIVE COMPUTER SIMULATION OF A 3-COLOR LIDAR SYSTEM. J. I. Mukula, Department of Geophysical Sciences and G. E. Copeland, Department of Physics, Old Dominion University, Norfolk, VA 23508.

A 3-color raman range-resolved lidar computer simulation is performed via an airborne platform traversing a fossil fuel power plant. The program's design allows the input of atmospheric buoyant forces and plant dynamic conditions to realistically approach the actual conditions which are pertinent to the system response.

The range resolved backscattered signals involve the fundamental infrared (1.065-6 μ m), the second harmonic or green portion (.5320E-6 μ m), and the raman shifted (.6073E-6 μ m) wavelength. Subsequent returns at the detector consist of photons and current with a Maxwellian noise added.

Profiles of the data indicate the scattering ration at specified elevations, and ideally, a distribution of the specific particulate in a plume or possible a localized airshed.

1978 SOUTHEASTERN VIRGINIA URBAN PLUME STUDY: FIELD MEASUREMENTS. D. S. McDougall¹, G. L. Gregory² and H. S. Wagner³. Langley Research Center, NASA, Hampton, VA. 23665.

The Southeastern Virginia Urban Plume Study (SEV-UPS) is a multiyear program to evaluate the performance of unproven NASA remote sensors designed to measure urban air pollution from surface and airborne platforms. As part of the July 10-28, 1978, SEV-UPS activity, several experiments were performed to measure the photochemically produced ozone and its associated primary precursors upwind, within, and downwind of the Hampton Roads, Virginia urban complex. Air quality (O₃, NO, NO₂, CH₄, THC, CO, and N₂O) and meteorology (wind vector, temperature, dewpoint, solar insolation, and mixing layer height) parameters were measured from a variety of aircraft, surface, and balloon platforms.

On July 24, the daytime variation of photochemically produced ozone in an urban area (20 km by 20 km box centered in the source area) was found to vary from 45 ppb (0600 a.d.t.) to a maximum of 105 ppb (1500 a.d.t.). The rise is attributed to O₃ re-entering the urban box due to a sea-breeze wind shift. On July 27, the downwind aging, transformation, and transport of pollutants from an urban plume were measured. Although the day was characterized by broken clouds and moderate temperatures, the airborne O₃ increased from an upwind value of 60 ppb to a downwind (4-6 hours aging) level of 100 ppb. For contrast, a similar experiment performed August 4, 1977, during clear skies and high temperatures, showed downwind O₃ levels to be as high as 150 ppb.

TROPHIC RELATIONS AMONG YOUNG-OF-YEAR SPORT FISH SPECIES IN THE LITTORAL ZONE OF VIRGINIA RESERVOIRS. J. J. Ney, F. D. Ricci¹, and W. R. Reynolds². Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Food habits of coexisting young-of-year fishes were examined from summer cove rotenone catches in Claytor and Smith Mountain Lakes. In the former, diets of three endemic species, largemouth bass, crappie and smallmouth bass, were compared to the food habits of the exotic, white bass. Diets of the three native species demonstrated partial resource partitioning, but white bass food habits were congruent with crappie, indicating possible trophic competition. In Smith Mt. Lake, diets of native largemouth bass and stocked striped bass were analyzed. Food habits by major category did not differ significantly between the species, although striped bass fed more heavily on fish while largemouth bass utilized a high proportion of neustonic insects.

In both situations, dietary overlap between young-of-year native and exotic sport species indicates the possibility of trophic competition which may affect growth and survival. Predictions of impact of exotic introductions should include detailed analysis of this overlooked aspect of interspecific relations.

NITRIC OXIDE AND THE "SUNDAY EFFECT" IN URBAN ST. LOUIS. E. J. Prior and J. R. Schiess. NASA Langley Research Center, Hampton, VA 23665

Recent analyses of pollutant measurements within large urban plumes have suggested that ozone levels are often greater during Sunday than during the weekdays when traffic emissions are most concentrated. Correct interpretation of this trend, which has been called the "Sunday Effect," is of major importance for the development of pollution control strategies since the trend implies that limitations on auto emissions may not necessarily result in lowered local ozone levels. To investigate this question, we have analyzed high quality 1976 pollutant measurements from the St. Louis Regional Air Pollution Study (RAPPS) conducted by the Environmental Protection Agency. We examined Sunday and weekday averages and also compared the upwind, central urban, and downwind variations of the ozone levels. An empirical model has been constructed to describe the variability of the daily St. Louis maximum ozone levels for each day in 1976. The model shows that decreasing ozone levels in the urban St. Louis area are related to increasing nitric oxide emissions. The greater weekday nitric oxide levels result in a larger depletion of ozone during weekdays than during Sundays. These results represent statistical confirmation of the urban nitric oxide scavenging hypothesis that has been put forward recently based on smog chamber studies and theoretical modeling.

AN EMISSIONS INVENTORY SUITABLE FOR MODEL STUDIES OF AIR QUALITY IN SOUTHEASTERN VIRGINIA. E. E. Rensberg, G. E. Woodbury¹, and L. C. Quinn². NASA Langley Research Ctr., Hampton, VA 23665 and D. A. Brewer, Joint Institute for Advancement of Flight Sciences, Geo. Wash. Univ., NASA Langley Res. Ctr., Hampton, VA 23665.

One of the largest uncertainties in air quality modeling is in the specification of the source function due to area and point source emissions. Up to now, the area species emissions were available on an annual basis for each city or county in Virginia Region VI. The area compilation from vehicle traffic and other sources that is presented here has been distributed over 1 km² grids. The point source data can be superimposed on these grids by using a multiple point source model that includes plume rise information. Consistency checks have been made on the data to assure that the inventory is reasonable. The inventory has been computerized so that it can be more easily updated in the future. These source function data are being applied to a box model calculation of air quality during the summer of 1978, and the results are to be compared with field measurements of ozone and its precursors over that same time period.

A STUDY OF LINEAR STATISTICAL CORRELATIONS BETWEEN ATMOSPHERIC OZONE CONCENTRATIONS AND ABSOLUTE HUMIDITY IN NORFOLK, VIRGINIA, 1977. T. L. Rettig, G. E. Copeland, Dept. of Physics, Old Dominion University, Norfolk, Virginia 23508

Barometric pressure, atmospheric ozone concentrations, temperature and relative humidity readings were measured at ODU Norfolk, VA and the Norfolk International Airport during the summer of 1977. These data were processed to find linear correlations. A -0.052517 correlation coefficient was found to exist between ambient ozone concentrations (ppb) and absolute humidity (g/m^3) using all data. A correlation of -0.062783 for night time conditions and of -0.048315 for daily time was obtained from the same data. A correlation of 0.631192 was found to exist between ozone concentrations and temperature (celsius) using all data. A correlation of -0.153991 was found between ozone and pressure (TORR) and a -0.669587 correlation between ozone and relative humidity (%) using all data.

In conclusion, no significant correlations exist between ambient ozone and water content of the atmosphere.

MUNICIPAL LANDFILL, LEACHATE IN THE GROUND AND SURFACE WATER, CHESAPEAKE, VIRGINIA. I. HEAVY METALS. J. H. Rulo. Dept. of Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

The City of Chesapeake, Virginia, has been using pH and Cl^- as routine monitoring parameters for leachate detection at its municipal landfill. Water from two landfill monitoring wells, two private wells near the landfill, and four surface water stations were analyzed. The pH, solids, and Cl^- levels at one monitoring well indicate that it is being influenced by nearby saline canal water. There was no evidence that landfill leachate was reaching the second well. The presence of an impervious clay layer suggests that the present monitoring wells may be too deep to detect any leachate movement. Levels of Zn, Cu, and Cd in the monitoring wells probably originated from dissolution of the galvanized well pipe. No significant levels of Cd, Cr, Cu, Ni, Pb, or Zn were found in the surface waters or two private wells near the landfill. It is concluded that Cl^- is not a desirable parameter for monitoring landfill movement, especially near the saline surface waters. Near surface stratigraphy, the groundwater table, and surface drainage indicate the potential for leachate movement from the landfill area toward adjacent waterways. ODURF Summer (1979) Grant #GR-12.

SIMULATION OF INDUCED FLUORESCENCE OF PHYTOPLANKTON IN THE MARINE ENVIRONMENT. W. L. Statton* J. W. Campbell, NASA Langley Research Center, Hampton, VA 23665

In recent years, NASA Langley has been engaged in remote sensing of the marine environment using lasers. The LIDAR (Light Detection and Ranging) technique has been successfully applied to determining *in vivo* fluorescence of chlorophyll *a*, both in the laboratory and the field. Chlorophyll *a* is the essential photosynthetic pigment found in all plant life and is important to the entire food chain. Chlorophyll *a* measurement techniques previously available to marine scientists include only those that require water samples from the body of water under examination. To alleviate the necessity of water sample collection and the resultant restrictions on coverage of surface sampling, a multispectral remote fluorosensor system has been under development to map chlorophyll *a* contained in algae from a helicopter or low-flying airplane.

To study the accuracy of this system, we are developing a computer model that simulates the fluorescence energy returned by algae when it is excited by light of various wavelengths. The model makes use of a multilayered water column in which chlorophyll *a* and light attenuation are varied with depth. Simulated fluorescence data are fed into the algorithm which estimates the chlorophyll *a* concentration assuming a uniform chlorophyll concentration with depth, and uniform attenuation with depth. Resulting estimates of chlorophyll *a* are then compared with the true concentration.

REMOTE SENSING OF THERMAL PLUME DYNAMICS NEAR THE SURRY NUCLEAR POWER STATION ON THE JAMES RIVER. T. A. Talay,* NASA-Langley Research Center, Hampton, Va 23665

Remote sensing of thermal discharges entering receiving waters offers the advantages of determining synoptic and temporal distributions without the requirements of extensive *in situ* surveys. The discharge dynamics may be related to specific riverflow, tidal, and bathymetric conditions.

On May 17, 1977, the NASA Langley Research Center conducted a remote sensing experiment over the James River, whereby thermal scanner data for the thermal plume near the Surry nuclear power station were obtained for six overpasses by the experiment aircraft. These data provided discrimination of flow patterns over most of one tidal cycle.

The resultant thermal mappings show the direct response of the thermal plume to the combined riverflow and tidal currents, and the channeling effects of the surrounding bathymetry. For the day of the experiment, excess temperatures for the plume above ambient river waters did not exceed 2°C except for small areas around the discharge. The thermal mappings also demonstrate the nonhomogeneous ambient temperature structure in the river caused by sunlight heating effects during the course of the day.

A SUMMARY OF THE METEOROLOGICAL CONDITIONS AND THE VERTICAL CARBON MONOXIDE PROFILE IN THE ST. PETERSBURG, FLORIDA AREA: 14-17 AUGUST, 1978. David A. Topping, Jr.* Dept. of Physics, Old Dominion Univ., Norfolk, VA 23508

During 14-17 August 1978, several tests of The MAPS (Measurement of Air Pollution from Satellites) remote sensor were made from an aircraft over the St. Petersburg, Fla. area. The aircraft was equipped to measure outside air temperature and dew point and to collect samples of the outside air. Gas chromatographic analysis of the samples for CO concentration, along with the temperature data, allowed construction of vertical profiles of the meteorological conditions and corresponding CO concentrations. This report presents and discusses these profiles.

Geology

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

CADMIUM-ZINC RATIOS IN SPHALERITES FROM THE CENTRAL SHENANDOAH VALLEY, VIRGINIA. Brian D. Baldwin* and W. C. Sherwood. Dept. of Geology, James Madison Univ., Harrisonburg, Va., 22807

Sphalerite was mined as a zinc ore in past years at several locations in the central Shenandoah Valley. As a result of similarity to zinc, cadmium occurs by isomorphous substitution in almost all zinc ores. The purpose of this study was to determine Cd/Zn ratios for a number of sphalerite samples. These ratios could then be compared to published ratios and tested for trends based on geographic distribution or host rock type.

Samples were taken from 28 sphalerite showings located in a linear trend along the strike of the dolomitic upper Beekmantown formation. Solutions made in a mixture of nitric and tartaric acids were dried, then redissolved and filtered. The Cd/Zn ratio was determined by atomic absorption spectrophotometry.

The results showed that the samples could be separated into two categories based on type of host rock. Using Cd/Zn x 1000, sphalerite from recrystallized dolomite showed a mean of 22.3 and from the brecciated dolomite a mean of 7.9. These values were higher and lower respectively than the published average for sphalerites occurring in the eastern U.S. Also discovered was a slight decrease in the ratio, and a color change in the sphalerite, from the northern to southern sample sites.

VARIATIONS IN GRAIN SIZE PARAMETERS AND BEACH PROFILES DURING A TIDAL CYCLE AT FORT STORY, VA., Paul R. Bowen* Albert W. Moore* Inst. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508

This study examines an unprotected beach environment during a tidal cycle to observe changes in both grain size distributions and small scale profile variations. The coarsest sediments were found in the vicinity of the wave plunge point. A secondary maximum of coarse sediments located further onshore appeared to be the result of uprush and backwash collisions. The beach profile showed correlation between erosional areas and coarse mean grain size. Accretional deposits located just seaward and landward of the wave plunge point migrated with the waves during the tidal cycle. Profile changes suggest that net erosion is associated with the flood, resulting in maximum net erosion at about high tide. Even more predominant net deposition was observed during the ebb, with resultant net deposition during the tidal cycle. Generally, sorting was progressively better toward the dune line and skewness was predominantly negative with some positive skewness in the vicinity of the wave plunge point.

THE SEDIMENTOLOGICAL AND PALEONTOLOGICAL SIGNIFICANCE OF CHAMA CONGREGATA FROM THE YORKTOWN FORMATION (EARLY ELOCENE) IN SOUTHEASTERN VIRGINIA. Felicia M. Boyd. Dept. of Geology, College of William and Mary, Williamsburg, Va. 23185

Chama congregata are found abundantly in coastal plain sediments throughout southeastern Virginia. The *Chama* beds reach a maximum thickness of 4.5 m. along the north bank of the James River. The beds intertongue with sand and silt to the east and south and are masked by other shells or are truncated to the north and west. *Chama* are gregarious, inequivalvar, attached, marine bivalve. *Chama* occur as disseminated shells or in aggregates in the Yorktown Formation. The organisms cement their shells to a hard substrate or, in sandy environments, to other shells. The encrusting *chama*s build prominent three-dimensional structures which serve not only as massive substrates for organisms, but are also traps and binders for fine-grained muds and biofragmental sands. *Chama* shells provide a substrate upon which gastropods, sponges, annelids, bryozoa, barnacles, and bryally attached bivalves attach and find protection. *Chama* shells are commonly bored, and the weakened shells are reduced to sand-sized particles by waves and currents. Examination of *Chama* beds along the James River in Virginia, including sediment analysis and a study of spatial relationships, has revealed the importance of the organism as a particle, a sediment trap and binder, and a substrate.

STRATIGRAPHY AND GEOMORPHOLOGY OF LATE PLEISTOCENE DEPOSITS OF THE NORTHERN NECK BETWEEN THE CORROTORIAN RIVER AND THE CHESAPEAKE BAY, VA. K.M. Farrell*, Va. Inst. of Marine Science, Gloucester Point, Va. 23062.

Sediments and topographic features of the Northern Neck provide evidence for a single transgressive-regressive episode in the late Pleistocene.

The dominant landforms in this area consist of 1) a north-trending scarp (toe at 14 m) that parallels the Rappahannock River, 2) an upland 18 to 28 m north of this scarp, 3) an estuarine plain at 4 to 14 m south of this scarp, 4) a prominent north-trending scarp (toe at 6 m) that truncates the northwest-trending scarp, and 5) a plain (≤ 6 m) east of the north-trending scarp.

The Pleistocene sequence in the vicinity of the White Stone Bridge consists of a discontinuous peat bed (paludal) overlain successively by a *Rangia*-bearing sandy mud (oligohaline fauna) and a muddy sand with abundant *Crassostrea* and *Mercenaria* (mesohaline to euhaline fauna). A fine to medium crossbedded sand which grades upward into fine sand conformably overlies the muddy sand. The upper sand unit coarsens seaward and pinches out upstream. East of the north-trending scarp sandy mud predominates.

During Sangamon time when sea level was rising to a maximum of 14 m estuarine sediments were deposited in the ancestral Rappahannock River and in the ancestral Chesapeake Bay. A split formed at the mouth of the ancestral Rappahannock. As sea level fell a north-trending shoreline was cut at 6 m.

PRELIMINARY REPORTS ON THE SALTVILLE PLEISTOCENE BONE BEDS; REGIONAL GEOLOGY AND GEOMORPHOLOGY. Jan Stocking*, John Thompson*, and Charles S. Bartlett, Jr., Dept. of Geology, Emory & Henry College, Emory, Virginia 24327.

The brinefield area of Saltville, VA is underlain by shale and evaporites and is bounded on the north by limestone, shale and sandstone, all of Mississippian age. On the south are Cambrian and Ordovician carbonates and shale. Prominent structural features include the Greendale Syncline and the Saltville thrust fault.

It was determined that a rapidly flowing stream occupied this valley in Pleistocene time. Evidence includes cross-bedding, rounded pebbles, lack of intrabasinal source for some pebbles, lack of rounded pebbles in present basin streams, and the scattered and disarticulated bones. A study of pebble composition indicates these formations as sources: algal chert, Honaker Formation; oolitic chert, Copper Ridge Formation; sandstone and siltstone, Price Formation.

There are two possible origins for this stream. The North Fork of the Holston River may have entered the valley through one or both gaps to the north of town and exited along McHenry Creek. This is unlikely since the exit is 80 feet higher than the entrance. It is more probable that drainage to the south of the area flowed to the northeast, emptying into the North Fork Holston River through the two gaps at Saltville. Recent piracy has modified the upper stream course by diverting McHenry, Keywood and Stonemill creeks.

THE FARMVILLE TRIASSIC BASIN: AN INTEGRATED GEOLOGICAL/GEOPHYSICAL STUDY. Gerald P. Wilkes and David K. Lasch*. Va. Div. of Mineral Resources, Charlottesville, Va. 22903

Two geologic cross-sections of the Farmville Triassic Basin are proposed based upon two-dimensional gravity modeling and geological implications. Two gravity surveys with station spacing ranging from one-quarter mile to one mile were conducted along US 60 and SR 636 in Buckingham and Cumberland Counties, Virginia. Fifty-nine gravity stations were occupied. Density values were obtained from rock samples collected adjacent to and within the basin. Traverse along US 60 and SR 636 provided profiles nearly perpendicular to the strike of the Triassic sediments.

The US 60 traverse (northern profile) crossed the basin where the surface outcrop of Triassic sediments is relatively narrow whereas the SR 636 traverse (southern profile) crossed a wider and more diverse group of Triassic sediments. The Piedmont crystalline rocks surrounding the Triassic sediments were assumed to be similar for both profiles.

Investigations imply a complex fault system associated with the paleodeposition of Triassic sediments. A high-angle western border fault has been documented and supported by the presence of fanglomerates and arkosic sandstones. A western border fault is included in both gravity models. The gravity model of the northern profile indicates a system of faults at the eastern border of the basin. Gravity modeling of the southern profile indicates a fault at the eastern margin of the basin.

PRELIMINARY REPORTS ON THE SALTVILLE PLEISTOCENE BONE BEDS: 1978 EXCAVATION AND RESULTS. R. Stephen Surbaugh* and Charles S. Bartlett, Jr., Dept. of Geology, Emory and Henry College, Emory, VA, 24327.

Excavations in Fall, 1978 at Saltville, VA encountered a late Pleistocene Age vertebrate bone-gravel bed in six test sites at depths to seven feet. Ray (1967) obtained a radio-carbon date of 13,460 plus or minus 420 years (11,510 B.C.) from a tusk fragment excavated nearby in 1967.

Examples of Proboscidean, including *Mammuthus americanum* (American Mastodon) and *Mammuthus primigenius* (Woolly Mammoth), were numerous. Of the 1401 total recovered remains, 1039 are Proboscidean bone, teeth and tusk fragments. Other animals represented are listed in decreasing order of recovered remains: *Ereus* sp. Indet. (horse), *Odocoileus virginianus* (deer) or *Rangifer* (caribou), *Bootherium* (musk-ox), *Megalonyx jeffersoni* (ground sloth), and turtle fragment.

The deposit consists of disarticulated bone fragments (generally badly worn and rounded), mixed with highly rounded chert, limestone, and other rock pebbles, sand, clay, and silt. The formerly porous bone (carbonate-apatite or fluor-apatite) has been permineralized with aragonite, calcite, and iron sulfide. No evidence was found of previously speculated in-situ death assemblages associated with nearby salt springs. The badly worn remains indicate that they have been transported from considerable distance upstream, suggesting the probability of other floodplain bone deposits in parts of the ancient valley.

Materials Science

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

SUBCRITICAL CRACK GROWTH IN ASTM A 106 PIPELINE STEEL, T. A. Adler*, M. R. Louthan, Jr., and R. P. McNitt, Mat. Eng. & ESM, VPI, Blacksburg, VA 24061

Crack propagation tests with compact tension samples of ASTM A 106 pipeline steel in gaseous oxygen and hydrogen show that hydrogen increases the ease of crack growth, causes a change in the mode of failure (from microvoid coalescence to a cleavage-like failure) and decreases the critical J integral (fracture toughness). A significant amount of plastic deformation occurs prior to and during crack growth in hydrogen, but the amount of plastic deformation is much less than in oxygen. Even though the amount of plastic deformation prior to crack growth is reduced by the presence of hydrogen, hydrogen has relatively little effect on the load-displacement curve and the size of the Luders strain regions surrounding the crack tip until crack growth initiated. This indicates that hydrogen effects are localized to the near crack tip region.

A PHOTOELASTIC METHOD FOR THE STUDY OF WATER DIFFUSION IN DENTAL COMPOSITES. R. E. Barker, Jr., F. E. Wanner, Jr., O. C. Hodgins, and K. R. Lawless, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

A study has been undertaken to utilize changes in optical birefringence to determine the effects of absorption and diffusion of water into a commercially available BIS-GMA (adapticTM) resin-quartz composite and on an experimental BIS-GMA resin. Observations with the polarizing microscope show that extensive changes in colored birefringence patterns occur near the edges and about defects in samples. The changes are dependent on time and temperature and represent related changes in the residual stress field. A relatively sharp colored boundary about $\frac{1}{2}$ mm wide appears around the edge of the sample, often involving nearby voids.

At 37°C the sorption data indicate that $D = 4.92 \times 10^{-2} \text{ b}^2/t_{0.5} = 4 \times 10^{-11} \text{ m}^2/\text{sec}$, where $t_{0.5}$ is the time at which the water sorbed is half the equilibrium value. Typically the equilibrium water sorption observed from this experiment is about 0.8%. The methods for analyzing the diffusion data were similar to those described by Crank, Jain, and Barker.

Further experiments to refine the techniques and determine the possible effects of swelling on D are underway.

This study was supported by NIDR Grant No. DE 03925-04.

IN-SITU HVEM TENSILE TESTING OF HE IRRADIATED 316 SS AT LOW STRAIN RATES. J. I. Bennetch, J. A. Horton, and W. A. Jesser, Materials Science Dept., Univ. of Va., Charlottesville, Va. 22901

In order to investigate the effect of helium on the fracture of 316 SS, in-situ HVEM tensile studies were conducted on samples as they were being irradiated, to high helium doses (>2 atom fraction) and at high temperatures ($\sim 600^\circ\text{C}$). These samples, tested at 600°C and at strain rates 10^{-4} sec^{-1} , had a large helium bubble population produced by irradiation. Under an applied stress, cracks characteristic of both relatively ductile or brittle behavior were observed to grow. Typically it is found that a loss of ductility in 316 SS occurs upon helium irradiation to much lower doses (10^{-5} atom fraction) when tested at similar test temperatures (700°C) and strain rates ($4 \times 10^{-4} \text{ sec}^{-1}$). Dislocations apparently sweep bubbles from the grain interior towards the grain boundary thereby weakening the samples at these low strain rates. Bennetch and co-workers observed not only an increase in bubble population on grain boundaries as irradiation progressed, but also in slip bands in front of a crack tip, suggesting brittle behavior. In addition, a decrease in bubble population in areas of plastic deformation in front of some crack tips was observed in the same sample, suggesting perhaps more ductile behavior. Crack propagation mechanisms for these phenomena will be discussed. (Supported by a grant from DOE.)

SIMULATION OF HIGH PRESSURE HYDROGEN ENVIRONMENTS BY CATHODIC CHARGING TECHNIQUES, W. H. Buttrill*, and M. R. Louthan, Mat. Eng., VPI, Blacksburg, VA 24061

Efficient and safe utilization of materials for the transportation and storage of gases containing hydrogen dictate the development of safe, convenient and effective test methods for characterization of candidate materials in hydrogenous environments. Testing methods currently employed to measure the environmental effects of hydrogen use high pressure gaseous systems which are necessarily large, costly and require extensive safety provisions. These test constraints can be avoided by the simulation of gaseous hydrogen at the surface of metals by the electrolytic evolution of hydrogen, H_2 , thus producing high effective hydrogen pressures. An experimental test facility has been constructed in which electrolytic evolution of hydrogen is occurring simultaneously on the surfaces of a tensile specimen and a permeation membrane of the same material within the test cell. The test cell is integrated with a tensile testing machine enabling the measurement of mechanical properties of the tensile specimen during electrochemical charging. The permeation rate of hydrogen through the membrane is measured and shown to be equivalent to an effective pressure of gaseous hydrogen. Initial tests have shown that the system has several distinct advantages. The effective hydrogen pressures attained by these techniques exceed those readily obtained by conventional techniques. The complete test cell can be constructed and operated at a minimal expense and is quite safe because the small volumes of hydrogen gas which are evolved.

THE EFFECTS OF MOISTURE ON THE DYNAMIC BEHAVIOR OF GRAPHITE EPOXY COMPOSITES. E. T. Camponeschi*, and W. W. Stinchcomb, Department of Engineering Science and Mechanics, Va. Poly. Inst. and State Univ., Blacksburg, Va. 24061.

The objective of this work was to determine the effect of moisture absorption on the dynamic response of graphite epoxy composite beams. Forced vibration tests were conducted in order to determine the storage modulus and damping ratio in the beams. These tests were performed for beam moisture contents ranging from 0 to 0.8 percent of the initial dry weight. The results indicate that the storage modulus is unaffected by moisture absorption, while in laminates that are matrix controlled, moisture increases the damping ratio.

RACTURE CHARACTERISTICS OF Al-Cu ALLOYS CONTAINING θ' AND θ PRECIPITATES. I. Chan, and H. G. F. Wilsdorf. Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901

The influence of the semi-coherent θ' and incoherent θ precipitates on the fracture behavior has been investigated through *in situ* experiments in a high voltage electron microscope (HVEM) and post fracture studies with transmission (TEM) and scanning electron microscopy (SEM). The findings showed that void initiation took place in the matrix as well as at precipitate-matrix interfaces. Crack growth was achieved by three dimensional void coalescence. Dislocation cells were present along the crack in the thicker regions above 400 nm. Structures bounded by zig-zag contours were observed at the fracture surface by TEM representing the last stage of the final separation. Beginning with a discussion of fracture surfaces as seen in the SEM, the results obtained from HVEM and TEM could be brought to bear on the fracture mechanism in precipitation hardened Al-Cu alloys.

DIFFUSION COEFFICIENTS FOR LIQUID PbSnTe. Ivan O. Clark*. Flight Electronics Division, NASA, Langley Research Center, Hampton, Va. 23665

In the absence of convection, the primary material properties governing the time necessary to obtain steady-state growth of a crystal are the diffusion coefficients of the material. Research is underway in the Flight Electronics Division of NASA/Langley Research Center to determine the diffusion coefficients for the $Pb_{x}Sn_{1-x}Te$ system in liquid phase. This research consists of determining the solutal diffusion coefficients by means of an isothermal modified-Löschmidt cell technique. The thermal (Sorot) diffusion coefficients are also being determined by means of a modified Löschmidt cell in a thermal gradient.

This research is in support of experimental and theoretical research into the growth of semiconductor materials in a low-g environment which is presently underway in the Flight Electronics Division of NASA/Langley Research Center.

ACOUSTIC EMISSION: ITS OCCURRENCE AND CAUSE IN 7075 ALUMINUM. John C. Duke, Jr., Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

During the quasi-static tensile deformation of 7075 Aluminum elastic strain energy is released periodically and may be detected nondestructively by means of acoustic emission sensors. The acoustic emissions however do not occur uniformly with deformation, but their occurrence is repeatable from test to test. A variety of heat treatment conditions have been examined and provide considerable insight into the possible causes of the emissions.

Considering the results of the acoustic emission monitoring in light of the results of fracture toughness investigations provides an explanation of the sources of these emissions. Distinct regions are apparent in the acoustic emission behavior which appear to result because of different emission sources. The findings support the contention that the emissions result from the fracture of inclusions as well as dislocation mechanisms. Such a detection capability emphasizes the potential of this monitoring technique for revealing the nature of the deformation process in materials.

This work was supported in part by the Air Force Office of Scientific Research (AFSC) United States Air Force.

INTERFACIAL VOID FORMATION IN BORON FILAMENTS. J.W. Eason*, and F.E. Wawner. Dept. of Materials Science, University of Virginia, Thornton Hall, Charlottesville, VA 22901

Boron filaments were annealed in various atmospheres and in vacuum (10^{-7} Torr). Relatively large axial contraction was observed during the annealing process. A dependence of contraction on concentration of oxygen in the atmosphere was found. This oxidation of the boron resulted in large void formation at the boron-tungsten boride core interface, suggesting the mechanism of vacancy diffusion to the interface.

HARDNESS OF POLYCRYSTALLINE STEEL WHISKERS GROWN IN VARIOUS MAGNETIC FLUXES. T. I. Ejim* and H. G. F. Wilsdorf. Dept. of Materials Science, Univ. of Va., Charlottesville, VA. 22901

Polycrystalline steel whiskers grown by chemical vapor deposition (CVD) in the presence of a magnetic field exhibit high strengths of up to 80GPa. One of the various parameters that could affect their strength is the magnitude of the magnetic flux during growth. This paper concentrates on the effect of the magnetic field strength on the hardness and strength of polycrystalline steel whiskers. A Riehle micro-hardness tester was used in obtaining the Vickers hardness reading of batches of whiskers grown in different magnetic field strengths. The reading increased with an increase in magnetic field strength up to about 1200 gauss. However, the data showed a moderate decrease with the flux increasing to 2200 gauss. It was also found that the hardness of the whiskers showed no dependence on diameter over the range of diameters investigated (5 μ m to 60 μ m). The strength of the whiskers was deduced from hardness readings using the Cahoon hardness-strength relationship $\sigma = H/2.9$ where σ is the ultimate tensile strength and H is the Vickers hardness.

THE CATALYSIS AND INHIBITION OF THE THERMAL OXIDATION OF GRAPHITE FIBERS. B. M. Ence*, D. M. Esterling*, The George Washington University/JIAFS, NASA Langley Res. Ctr., Hampton, VA 23665.

At the upper service temperature of polyimide composites (644°K) some commercial graphite fibers oxidize readily while others remain very stable. The reasons for these differences were studied and a simple procedure to stabilize the fibers was developed.

Previous correlation studies indicated that residual sodium (a known catalyst for graphite oxidation) in the fibers and possibly the degree of graphitization of the fibers determined their stability. Tests were performed on Hercules AS (an unstable fiber) and HTS (a stable fiber) which seemed to verify the correlation studies.

Phosphorous and its oxides inhibit the oxidation of graphite. In this study a treatment with H_3PO_4 was developed which substantially decreased the oxidation rate of both the stable and unstable fibers, e.g. a factor of 20 reduction for the AS fibers at 755°K.

STUDY OF THE MELTING BEHAVIOR OF SMALL BISMUTH CRYSTALLITES. W.W. Gile* and W.A. Jesser. Dept. of Materials Science, University of Virginia, Charlottesville, Va. 22901.

An experimental study of size-dependence of melting has been ongoing for over 20 years by different investigators. As technological advancements permitted, improvements in the techniques of investigation have occurred. In this vein, this research is performed in a good vacuum (2×10^{-7} torr) using *in-situ* evaporation. The melting of individual particles was detected by dark-field electron microscopy. When a particle melts, it will lose its crystalline structure and therefore its dark-field image will disappear. The experiments were performed as follows: the sample was heated taking micrographs at particular, known temperature intervals until all the particles have melted. These micrographs were analyzed by two different methods to ascertain explicit results on the melting temperature of the particle versus the inverse particle radius. The results from these two methods for bismuth will be compared along with the effect of oxidation on the results. The present results for bismuth will also be compared with those of other investigators of bismuth along with an explanation of the discrepancies between them.

(The financial support of the Army Research Office is gratefully acknowledged.)

A TENSILE TESTER FOR GLASS FIBERS WITH CONTROLLABLE ENVIRONMENT. Hilary T. Godard* and H. G. F. Wilsdorf. Dept. of Materials Science, Univ. of Virginia, Charlottesville, Va. 22901

The need arose for a device to produce and tensile test thin glass fibers in a variety of environments. A technique was developed for thin fiber production by remote control. Combined with a small load tensile tester of unique design, peripheral electronics, and plumbing, this machine fulfilled the requirements. In line with research goals, the capability of metalization was added. Applications involve investigation of water vapor degradation of glass fiber strength, and possible barriers to this degradation.

A NOVEL METHOD OF FINDING BOILING POINTS FROM VAN DER WAAL'S GAS CONSTANTS. P. B. Haney* and W. A. Jesser. Dept. of Materials Science, Univ. of Va. Charlottesville, Va. 22901

This Method involves taking van der Waal's Equation of State, $P = RT/(V-b) - a/V^2$ where usual notation is employed, and setting the equation in the cubic form in V.

The combination of coefficients of the cubic equation which tests for the real or imaginary character of the roots is called F and is too lengthy for inclusion here. When this function F is negative there are three real and unequal solutions for the molar volume V. It was found that even though the purpose of F is to characterize the roots, V, it also determines the boiling temperature T.

The most negative value of F corresponds to a relative minimum when F is plotted as a function of T. This relative minimum determines the boiling point of the liquid at a pressure of 1 atmosphere. The explicit solution for T which minimizes F is given by: $T = [a/(2bR) - 6bP/R + ((6bP/R - a/(2bR))^2 - 6bP/R^2 + 60aP/R^2)^{.5}]/6$. A comparison between this Method and the rule of Guldberg, $T = (2/3) \times 8a/(27bR)$ will be presented. For van der Waal's bonding and small values of a, the above Method is accurate to less than ± 0.5 degrees Kelvin.

MICROSTRUCTURAL ASPECTS OF SEMI-BRITTLE FRACTURE OF BERYLLIUM CRYSTALS. D. E. Hedke* and H. G. F. Wilsdorf. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Mechanical testing at room temperature of beryllium single crystals oriented to exclude basal slip, in conjunction with post fracture examination by scanning and transmission electron microscopy (SEM and TEM) has defined the occurrence of a ductile to brittle transition dependent on the rate of elongation in tension. The semi-brittle regime occurs essentially at rates of elongation less than about .05 cm/min (8.333×10^{-4} cm/s) and is characterized by fracture through well defined prismatic ligament separation. Above this elongation rate fracture generally occurs through cleavage on the $\{10\bar{1}0\} \times \{11\bar{2}0\}$ systems. TEM characterization strongly indicates volume element rotation about an axis perpendicular to stress axis as well as severe lattice distortion in interligament regions. The ductile to brittle transition is quantitatively defined on the basis of variation of the stress hardening exponent, n, as it occurs in the relationship $\sigma = K\epsilon^n$. σ , ϵ refer to true stress and true strain and K is the strength coefficient.

COMPRESSIVE STIFFNESS AS A MEASURE OF DAMAGE IN GRAPHITE EPOXY LAMINATES. A. L. Highsmith*, and K. L. Reifsnider, Department of Engineering Science and Mechanics, Va. Polytechnic Inst. & St. Univ., Blacksburg, Va. 24061

Previously, tensile stiffness has been related to damage in graphite epoxy laminates. This study examines the effect of damage on compressive stiffness. Varying degrees of damage were introduced into specimens via quasi-static and fatigue loading. Replication was used to characterize the damage state, and tensile and compressive moduli were measured. The effects of stacking sequence and damage on out of plane behavior, specifically elastic instability, are also examined.

RADIATION DAMAGE IN HE BOMBARDED STAINLESS STEEL THIN FOILS. L.V. Schiesterle Horton* and W.A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901.

In-situ helium ion irradiation experiments on thin foils of type 316 stainless steel, a candidate first wall material for proposed fusion reactors, have been conducted by means of a 200 kV light ion linear accelerator mechanically linked to the objective lens of a 500 kV HVEM. An ion energy of 80 keV, ion fluxes up to about $2 \times 10^{15} \text{ cm}^{-2} \text{ sec}^{-1}$, doses up to about $2 \times 10^{18} \text{ cm}^{-2}$ and sample temperatures ranging from about 500° C to 650° C were employed. In these experiments, the radiation damage process, including the onset of surface damage, was observed. In the lower temperature cases, the predominant type of surface damage was exfoliation. In the electron transparent regions of the samples, exfoliation usually occurred in circular patches. The patch diameter decreased with decreasing sample thickness. Exfoliation was observed on the front surface of the samples in regions of sample thickness of about 150 nm, which is less than the 281 nm projected helium range. In higher temperature cases, the predominant type of damage was blistering. In the electron transparent regions, blisters were observed to form in the thicker areas and buckled grains in the thinnest areas. Post-irradiation SEM examination showed the progression of damage from the electron transparent regions to the bulk areas was: buckled grains, blisters on the beam exit surface, blisters on both surfaces and, in the bulk areas, blisters on the front surface only. (Supported by D.O.E.)

DIFFUSE STREAKING IN TEM DIFFRACTION PATTERNS FROM PbSnTe.

R. W. Housley* and W. A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville.

Single crystal samples of stoichiometric PbSnTe were electropolished for transmission electron microscopy. Diffraction patterns of samples tilted to several different orientations show the NaCl structure. Also observed in the diffraction patterns were anomalous diffuse streaking and a number of extra diffuse spots which can be interpreted in terms of {100} sheets of intensity and reldos of intensity along the $\langle 100 \rangle$ directions of the bcc reciprocal lattice. The intensity of the diffuse reldos is high at cube corners and low at the cube center. In all diffraction patterns observed only two of the three possible {100} planes exhibited streaking in the diffraction pattern. The third streaking direction was always the one corresponding to the particular {100} plane which makes an acute angle of less than 55° with the plane normal to the electron beam. Some diffuse spots were selected to produce dark field images. Only general areas of intensity and extinction contours were visible in these dark field images. It is therefore likely that the reldos are produced by thermal diffuse scattering rather than plate-like precipitates or other usual origins. The support of NASA is gratefully acknowledged for this project.

POINT DEFECT NUCLEATION THEORY. R. A. Johnson, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

The theory for nucleation and growth of point defect clusters is commonly developed using a continuous size variable and continuous kinetic parameters. In the present work, the atomistic nature of the process is studied by writing a separate rate equation for each size cluster of irradiation-produced vacancies and self interstitials (up to a given maximum size for the model) and solving the ensuing set of coupled rate equations using computer techniques. The explicit system used as an example involves the nucleation and initial growth of clusters of interstitials at the onset of specimen irradiation. Both homogeneous and heterogeneous nucleation are treated, the latter by including trapping sites in the model, i.e., solute atoms with a binding energy for the mobile point defects. It is found that over a broad temperature range there should be appreciable nucleation of interstitial clusters in the transient period prior to the approach of single vacancy and interstitial concentrations to their approximate steady-state values.

(Work supported by the NSF through Grant No. DMR 78-07539)

LATTICE IMAGE STUDIES OF DENTAL ENAMEL. A. F. Marshall and K. R. Lawless, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Lattice imaging techniques with the TEM have been used to study the central defect often observed in crystals of hydroxyapatite from dental enamel. The central defect was resolved as a {100} lattice fringe in both longitudinally and crosscut crystallites, indicating a planar defect. The defect is of a phase nature and does not show diffraction contrast. Microdiffraction studies show the presence of hydroxyapatite only. Observations of lattice images from carious crystallites indicate the central defect in a site of caries attack.

INTERFACIAL ADHESION IN DENTAL COMPOSITE SYSTEMS. C. M. Montes-Gonzalez* and F. E. Wamer, Jr., Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Glass reinforced resins used in dental restorations undergo severe thermo-chemical variations in environment. This study concentrates on the effects by temperature and water on the interface between a commonly used resin (BIS-GMA) and a surface of nearly pure fused quartz. The debonding shear strength is measured with an Instron tensile tester from single "fibers" embedded in a button of the resin. Tests are made on samples immersed in water at 0°, 25°, and 80°C for an extended time (20 days), and on samples thermocycled in water and in a desiccator (dry) from 0°C to 80°C. The results are compared with the results of tests on samples prepared and tested at room-environmental conditions (T = 25°C). The interface is varied by changing the surface pre-treatment of the fibers. A silane coating is applied in two different ways, one using n-propylamine as a catalyst, and another, more common in industry, using acetic acid in an aqueous solution. A varying amount of silane on the interface is achieved by using various times for treatment.

This study was supported by NIDR Grant No. DE 03925-04.

DISK RUPTURE TESTING FOR HYDROGEN EMBRITTLEMENT, J. Murali*, M. R. Louthan, Jr., and R. P. McNitt, Mat. Eng. and ESM, VPI, Blacksburg, VA 24061

Pre-flawed specimens of AISI 1015 sheet steel were subjected to biaxial loading using high pressure gas. Testing was done to investigate flaw growth behavior in hydrogen-carrying pipeline steels. Circular specimens approximately 100 mm in diameter and 0.4 mm thick were subjected to internal pressure (oxygen or hydrogen) using the disk rupture technique. Bulge height and pressure were monitored using a LVDT and a high pressure transducer respectively. Gaseous hydrogen did not affect the pressure vs. bulge height curves even at large strains where for a given pressure, deflection in hydrogen was similar to that in oxygen. Hydrogen, however, lowered the rupture pressures by ~15-20%. All samples tested in hydrogen failed by development of a pinhole at the flaw and did not rupture whereas many of the samples tested in oxygen ruptured. This feature indicated that hydrogen carrying gas pipelines should leak before rupture which is safer than a catastrophic gas release. The results are correlated with tubular samples which developed similar leaks when subjected to internal pressure of hydrogen.

SOME EFFECTS OF GAS ENVIRONMENTS ON DEFORMATION AND FRACTURE OF POLYMERIC MATERIAL. T. E. Munns*, M. R. Louthan, Jr., D. D. Wight and R. P. McNitt, VPI, Blacksburg, Va. 24061

Many structural metals are embrittled when pulled to failure in gaseous hydrogen. However, little information is available as to the mechanical behavior of polymers in the presence of hydrogen. Two polymers, one crystalline and the other amorphous were tested at various pressurizing rates in oxygen (control) and hydrogen to determine if hydrogen induced effects were apparent. The polymers were crystalline polybutylene terephthalate (PBT) and impact grade polystyrene (amorphous with dispersed rubber). When tested in air at atmospheric pressure PBT exhibited a high degree of plasticity as evidenced by necking before failure while the polystyrene was brittle and showed stress whitening. In oxygen, the fracture strength of both PBT and polystyrene increased with increasing strain rate. In hydrogen, the fracture strength of PBT increased with increasing strain rate while the fracture strength of polystyrene remained constant. There were no significant differences in deformation or fracture appearance between PBT tested in oxygen or hydrogen. The degree of stress whitening was much higher for polystyrene samples tested in a hydrogen environment as compared to those tested in oxygen. From these results it is apparent that in an amorphous polymer, such as polystyrene, hydrogen suppresses the effect of strain rate on the fracture strength. There is no apparent effect of hydrogen on the fracture of the more crystalline polymer.

HOLE-SIZE EFFECT IN COMPOSITES. R. Prabhakaran. Dept. of Mech. Eng. and Mechanics, ODU, Norfolk, VA. 23508.

Hole-size effect in composites refers to the greater strength reductions in composites due to larger holes, the stress concentration factor remaining the same. Tensile tests have been conducted on a bidirectionally reinforced E glass-epoxy composite. Two series of tests have been performed, varying the width of the specimen along with the diameter of the hole in one and varying the hole diameter while keeping the coupon width constant in the other. An inherent size effect in the material, in addition to the hole-size, has been observed and taken into account in the data analysis.

The "inherent flaw size" according to the fracture mechanics approach as well as the "characteristic dimension" according to the two-parameter models have been considered. Both the dimensions were found to be dependent on the hole size, increasing with increasing hole diameter. For the range of hole sizes tested, the characteristic dimension was found to be approximately half of the inherent flaw-size.

Surprisingly, in the literature on the hole-size effect in composites, no mention has been made on the notch-size effect in metals which has been extensively investigated. It is suggested that a similar attempt be made to relate the hole-size effect to the microstructure of composites.

REACTIONS BETWEEN ALUMINUM FILMS AND TITANIUM SUBSTRATES. V. B. Rao* and C. R. Bouska, Dept. of Materials Engr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Samples of 1 μ m. Aluminum (Al) films, sputter-deposited on Titanium (Ti) substrates, were vacuum-annealed at 635°C for short times (4hr. and 1 hr.). X-ray diffraction analysis indicated that even after a 4hr., Al totally reacted yielding a single phase layer of TiAl₃. The layer thickness was determined in each case from the attenuation of the integrated intensities from the Ti lines below the TiAl₃-Ti interface. Comparison with the equilibrium thickness calculated from a mass balance of Al. atoms, indicated a partial dissolution of TiAl₃ at the interface after it was quickly formed. Also, the diffraction lines from c-Ti were broadened by an Al composition profile extending into the Ti substrate.

A computer program, modified for use with polycrystalline materials was used to simulate a diffracted intensity band for a Ti (101) reflection. The simulated band was made to match the experimentally obtained one, by varying the Al. composition profile. The final profiles contained a region near the TiAl₃ interface with a high composition gradient and a second region, where the composition gradient is small and the penetration distance is relatively large. The latter can be related to grain boundary diffusion.

FLUORIDE DETERMINATION IN DENTAL ALLOYS USING A RESONANT NUCLEAR REACTION. P. M. Natisan*(1), L. B. Johnson, Jr. (1) and R. O. Allen, Jr. (2), Dept. of Materials Science (1) and Dept. of Chemistry (2), Univ. of Va., Charlottesville, VA

In order to prevent the occurrence of secondary caries, fluoride in various forms has been incorporated into dental alloys. Although the fluoride appears to decrease the incidence of secondary caries, it also leads to enhanced corrosion of the dental amalgams. Research continues in an effort to incorporate fluoride into dental alloys in a manner which does not interfere with the essential properties of the amalgam. Consequently, it has become desirable to develop a method for accurately determining the amount of fluoride in treated dental alloys.

At the Univ. of Va., a microanalysis technique involving a resonant nuclear reaction was employed to analyze the fluoride content of treated dental alloys. Applying this technique to geological materials fluoride concentrations on the order of 1 ppm have been detected. In this analysis, high energy protons are used to bombard a sample initiating a variety of nuclear reactions including the pertinent resonant reaction for fluoride. This resonant reaction causes a series of nuclear decays emitting a characteristic γ -ray which can be measured. The yields, number of characteristic γ -rays detected per unit charge, of unknown and standard samples can be compared and the fluoride concentrations of the unknowns can be determined.

THE EFFECT OF HEAVY ION BOMBARDMENT ON NICKEL AND BINARY NICKEL ALLOYS. K. B. Roarty* and R. A. Johnson. Dept. of Materials Science, Univ. of Va., Charlottesville, VA. 22901

The study of radiation damage of materials is a field of present and future concern in that reactor materials, when exposed to high doses of radiation can swell due to creation of voids and cause reactor failure. Short-term high energy ion bombardment has been used to simulate the long-term exposure and damage of reactor materials. In this study, nickel and binary nickel alloys of 1 at % Al, Ti, Si or Mo were bombarded by 2.8 MeV Ni¹⁴ ions in a Van de Graaff accelerator at 675°C, 625°C, 575°C and 525°C. Using transmission electron microscopy, it was found that all additions suppressed void swelling, although the Si and Mo additions to a much greater degree. Peak swelling occurred at the higher temperatures, and high dislocation densities were found at the lower temperatures with dislocation structure progressing from loops and tangles to segregated line segments as the temperature increased.

(Work supported by ONR and NSF, Van de Graaff facilities provided by NRL)

RADIATION DAMAGE EFFECTS ON THE MICROSTRUCTURE OF NICKEL. M. L. Sattler* and W. A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

The microstructure of small-grained thin nickel films was studied by TEM techniques during and after bombardment with 80 keV He⁺ ions in an effort to simulate the effect of the environment on first-wall fusion reactor materials. The samples were chemical-vapor-deposited nickel thin films obtained by the thermal decomposition of Ni(CO)₄. Their initial microstructure consisted of dislocations and twins in large (600 nm) grains surrounded by smaller (30 nm) grains.

At low doses and dose rates (1.8 $\times 10^{17}$ ions/cm² and 7.1 $\times 10^{13}$ ions/cm²-sec, respectively) there appeared no prominent damage; grain sizes and grain arrangements remained unaltered. At high doses and dose rates (1.3 $\times 10^{18}$ ions/cm² and 7.5 $\times 10^{14}$ ions/cm²-sec, respectively) there was gross damage over the sample; small voids or bubbles decorated the grain boundaries while all shapes and sizes (10 to 200 nm) of cavities remained inside the grains; the area immediately next to the grain boundaries was denuded; no small grains remained, only large (800 nm) ones; grains with dislocations seemed to contain fewer cavities than those without dislocations. At intermediate doses and dose rates, damage was minimal; tiny cavities (~1.5 nm) appeared in the small grains; grain sizes and grain arrangements were unaltered. (Sponsored by a grant from DOE, Office of Fusion Energy.)

EFFECT OF SAMPLE THICKNESS ON DELAYED FAILURE HYDROGEN EMBRITTLEMENT. P. W. Smith*, M. R. Louthan, Jr., and R. P. McNitt, Mat. Eng. & ESM, VPI, Blacksburg, VA 24061

Sample thickness greatly influences the maximum stress at which 4340 steel samples fail when loaded in a four point bending fixture placed in hydrogen gas for a specific time. Rectangular samples (1/2"x2"x0.05 to 0.10") were stressed so that the top surface was in uniaxial tension prior to the samples and loading fixtures being placed in a high pressure autoclave. The autoclave was then evacuated, flushed with purified hydrogen and pressurized to the desired level (typically 2000 psi). Samples were exposed at room temperature for 120 hours then checked for failure. If failure had not occurred the samples were stressed to a higher level and returned to the autoclave for another 120 hour exposure. This procedure was repeated until the minimum failure stress was determined. Fresh samples were then tested to be certain that cumulative exposure effects did not distort the failure data. This data has shown that the failure stress decreased with increasing sample thickness, an effect which can be rationalized by a critical ligament theory. This theory suggests that a critical volume of steel must be at or above some minimum stress level before hydrogen induced cracking can nucleate. For the particular loading conditions tested, crack nucleation is apparently rapidly followed by failure so no analysis of crack propagation was attempted.

INSTRUMENTED IMPACT TESTING FOR ENVIRONMENTAL DEGRADATION OF STEELS, S. M. Stafford*, and R. P. McNitt, Mat. Eng. and ESM VPI, Blacksburg, VA 24061

Mechanical properties such as strength, toughness and ductility are typically functions of the rate of loading (strain rate) of metals. Increasing the strain rate usually decreases ductility and toughness thus "embrittling" a material. The Charpy impact machine has been a convenient means of obtaining material toughness at high strain rates and the addition of an instrumented top, integrating and recording devices provides a system to obtain load-displacement history during very high speed tests.

Hydrogen embrittlement in metals is commonly presumed to be emphasized by very slow strain rate testing. This is due in part to relatively slow diffusion of hydrogen to high strain energy sites. However high strain rate embrittlement may occur if the hydrogen were appropriately distributed by pre-impact static straining. Hence an experimental program involving a mild steel (A106) thought to be relatively passive to hydrogen and high strength (4140) steel known to exhibit hydrogen embrittlement was designed. The Charpy impact specimens have three pre test conditions; 1) no hydrogen-no preload, 2) hydrogen charged-no preload, and 3) hydrogen charged while-preloaded to near yield by a static load configuration similar to the eventual dynamic loading. In the latter configuration the static load is removed just prior to testing. The stress strain curves, max stresses, toughness and yield loads will be compared for both materials and the three loadings to obtain evidence of high strain rate hydrogen embrittlement.

NONDESTRUCTIVE EVALUATION OF FATIGUE DAMAGE IN COMPOSITE MATERIALS. P. C. Yeung*, M. N. Gibbins*, and K. L. Reifsnider. Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst., Blacksburg, Va. 24061

Flaw growth around an embedded flaw in the interior of a composite laminate has been investigated. Various non-destructive techniques, such as thermography, ultrasonics, and X-ray radiography, were utilized to monitor the damage development in these composites while under fatigue loading. The information obtained provided a valuable insight in the understanding of the complex nature and the extent of the fatigue damage growth. The results are then compared with sectioning studies, surface replication, and stiffness change measurements. (Aided by NASA grant NSG-1364).

Medical Science

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

A SCIENTIFIC ANALYSIS OF "LIE DETECTORS" AS INSTRUMENTS FOR THE PSYCHO-DIAGNOSIS OF HUMAN STRESS AND DECEPTION. John C. Bartone and Michael P. Kradz, American Health Research Institute, Annandale, Va. 22003.

A "science" of "lie detection" does not exist and never has in the history of man. A few specialties prefer acceptance that "lie detection" is real, practical and fearfully revealing. No instruments exist as "lie detectors." Furthermore, the symptom-psycho-somato-plex or overall effects of such machines on populations remains real but unexplored.

Instruments labelled "lie detectors" or other names as "voice analyzers" have one common attribute: to measure or record physiologic activity of various types as electro-dermal conduction or infra-sonic vibrational voice structure. These functions pertain to the mind/body or both as inverse psychosomatic phenomena. Stress, with all its unknowns, also creates physiologic fluctuations from somatic causality or psychic stress, and its symptomology adds to whatever aspect these devices divulge. The lie detection industry effectuates its practice by noting increased stress due to immoral behavior. Gross malpractice of science and medicine abounds with these devices. Consequently, the intricacy of psycho-diagnosis of human stress and deceptive practices remain idiopathic and semiological.

TOTALLY DISCONTINUOUS DNA SYNTHESIS IN TRANSFORMED HUMAN FIBROBLASTS. David E. Berry* and James M. Collins, Department of Biochemistry, Medical College of Virginia Campus, Virginia Commonwealth University, Richmond, Virginia 23298, USA

Normal diploid cells and their SV40-transformed counterparts represent logical systems for the study of the results of cell transformation. When normal human diploid fibroblasts (WI-38) are pulsed with ^3H -TdR, the earliest detectable DNA synthesized is in the form of small, 4.5 S "Okazaki fragments", which are subsequently converted to large (400 S) chromosomal-sized DNA. We have detected similar small pieces of DNA in transformed WI-38 cells (called 2RA). When both cell lines are pulsed for very short times, analysis by alkaline sucrose gradient sedimentation reveals both radioactive "Okazaki fragments" and larger radioactive DNA molecules. However, the distribution of radioactivity between small and larger pieces of DNA is quite different in the two cell lines. Extrapolation of the data to zero time reveals that the normal cell line contains 50% of the ^3H in DNA pieces smaller than 6 S and 50% of the label in DNA pieces larger than 6 S. The transformed cell line, however, contains 67% of the ^3H in DNA pieces smaller than 6 S and only 33% of the ^3H in DNA pieces larger than 6 S. These data argue that DNA synthesis in the transformed cells is totally discontinuous whereas DNA synthesis in normal cells appears to be semi-discontinuous. Supported by NCI grant CA-24158.

STUDIES OF A HUMAN ACARDIAC MONSTER. F.R. Bieber* and W. E. Nance*. Dept. of Human Genetics, Med. Col. of Va., Richmond, Va. 23298

Acadia, the total lack of a heart, is an unusual malformation that is unique to the twinning process. It occurs with an estimated frequency of about one in 100 twin pairs. We report studies of one such case, ascertained when a non-viable 322-gram malformed fetus was delivered as the second member of a twin pair. The first twin was a normal male, weighing 1967 grams at birth, and had no cardiac or other problems in the perinatal period.

The acardiac twin was grossly amorphous, with absent upper and malformed lower extremities, and a large omphalocele. Dissection revealed the absence of the heart, lungs, liver and kidneys, and presence of several isolated loops of gut. Skeletal structures, where present, were hypoplastic and malformed. The single gonad had failed to differentiate sufficiently for histologic sex determination. No other internal genital structures were found. The monochorionic, diamniotic twin placenta had large artery-artery and vein-vein anastomoses. The umbilical cord connected to the acardiac twin was marginally inserted and had only two vessels.

In only a few of the previously reported cases of acadia have genetic studies, including chromosome analysis, been conducted. Data from several genetic studies of this case will be presented and discussed.

METHYLGLYOXAL CATABOLISM IN BLOOD. R. B. Brandt and S. A. Siegel, Dept. of Biochemistry & MC/V/VCU Cancer Center, Va. Commonwealth Univ., Richmond, VA 23298

Methylglyoxal (MeG), a dicarbonyl has a potential role in growth inhibition. Catabolism of MeG occurs through the glyoxalase enzymes consisting of glyoxalase I (S-lactoyl-glutathione methylglyoxal lyase, isomerizing; EC 4.4.1.5) and glyoxalase II (S-2 hydroxyacyl glutathione hydrolase; EC 3.1.2.6), with glutathione as a coenzyme to form D-lactate (not the L-lactate of glycolysis). Due to the active glyoxalase system in many tissues, the direct determination of MeG is difficult. However, the product of its catabolism, D-lactate, may be measured to determine formed or exogenous MeG. An enzymatic stereospecific spectrophotometric assay involving reduction of NAD^+ was used for plasma D-lactate analysis. In normal humans the plasma D-lactate concentration was found to be 0.02 mM. When the glycolytic pathway in whole blood was inhibited *in vitro* with fluoride, a significant increase in D-lactate was found. Added MeG also caused increased formation of D-lactate. Specific glycolytic intermediates added to whole blood produced an increased plasma concentration of D-lactate, even when glycolysis was not inhibited. These findings indicate that some catabolites of glucose leads to MeG synthesis and suggest possible control functions for the glyoxalase enzyme system during impaired glycolysis that may be exploited for cancer therapy. (Supported by funds from the National Foundation for Cancer Research.)

HISTOCHEMISTRY AND ULTRASTRUCTURE OF RAT MASSETER MUSCLE AFTER LIDOCAINE TOXICITY. Francis M. Bush, Hugo R. Seibel and Melvin P. Dolwick. Div. of Oculusion and Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298

Lidocaine administered singly, subcutaneously or intramuscularly, into masseter muscle, induces a phase of degeneration lasting approximately two days followed by a return to the normal histology by about 45 days. The present paper describes the effect of intramuscular injection of 2% Lidocaine.

Myofiber enzymatic activity showed decreased phosphorylase, increased succinic dehydrogenase and increased adenosine triphosphatase (alkaline stable form ATPase). Damaged myofibers demonstrated leucine aminopeptidase and glucose 6-phosphate dehydrogenase activities that suggested autolytic processes involving macrophages. Leucine aminopeptidase was slightly present within fibroblasts. Glycogen, was absent from myofibers in early lesions but accumulated in adjacent myofibers.

Mitochondrial changes are related to increased succinic dehydrogenase activity while alterations of the sarcoplasmic reticulum correlates with phosphorylase disappearance. Myofibrillar disruption accounted for increased ATPase activity. Macrophage activity correlates with increased leucine aminopeptidase.

OBSERVATIONS ON NORS, QM HETEROMORPHISMS AND SATELLITE ASSOCIATIONS IN TWINS: AN MZ TWIN PAIR WITH A 14/21 TRANSLOCATION. C. R. Casson* and J. A. Brown*. Dept. of Human Genetics, Med. Col. of Va., Richmond, Va. 23298

The presence of human chromosome heteromorphisms has proved useful in zygosity determination. A recently developed staining technique, Ag-AS, makes possible the observation of a heteromorphic region (nucleolar organizer region (NOR)) in the ten acrocentric chromosomes (Nos. 13-15 and Nos. 21 and 22) in man. Metaphase chromosomes from a monozygotic twin pair possessing a 14/21 translocation were studied by a modification of the Ag-AS technique, counterstained with quinacrine mustard dihydrochloride and scored for NOR activity, QM heteromorphisms and satellite associations. An analysis of the variation in NOR activity between and within individuals revealed no significant differences between repeated observations in each individual and the observations across the pair. Estimates of the variance components of NOR activity for each acrocentric chromosome in the twins revealed a smaller variance component between the individuals than between repeated observations. The regression line that best fit the data by the least squares method had a slope of 1.09 and an intercept of 0.05; the 95% confidence interval for these values included a slope of 1 and an intercept of 0. A Pearsonian correlation between the mean NOR scores of the twins' chromosome pairs was highly significant ($p < .01$) with a coefficient of 0.97. These preliminary results suggest that the degree of NOR activity is characteristic for a particular chromosome.

DRUG-INDUCED ALTERATIONS ON GROWTH AND DEVELOPMENT: NEUROENDOCRINE AND PHYSIOLOGICAL ASPECTS. M. Ching, Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298

Chronic feeding of saline or D-amphetamine sulfate (AS, 1-5 mg/kg/day) or injection of codeine phosphate (CP) or phenobarbital (PB) (both 30mg/kg/day) to pregnant and lactating rats resulted in abnormal growth and development of male and female offspring. CP or the high dose of AS caused stunting of fetal growth. Conversely, feeding saline or low doses of AS enhanced somatic growth. The perinatal mortality rate was increased in litters of mothers administered CP, PB or AS. Precocious or delayed vaginal opening occurred in daughters of PB or AS-treated mothers, respectively. PB stimulated somatotropin releasing activity in hypothalami of newly weaned neonates without altering somatotropin release inhibiting factor (SRIF) stores. Pituitary and serum concentrations of somatotropin (STH) remained unchanged or declined following PB or CP treatment but STH stores increased after puberty. Offspring of saline-fed mothers showed increased hypothalamic content of SRIF and decreased luteinizing hormone releasing hormone stores coupled with an apparent rise in pituitary and decline in serum STH titers. Thus, the chemical agents employed in this study altered certain anatomical and physiological parameters associated with growth. This reiterates the need for proper control of diet and intake of medication during pregnancy. (Aided by grants from the Human Growth Foundation and AM 16557).

IN VITRO EFFECTS OF KEPONE. E. L. Carmines*, D. W. End*, R. A. Carcman*, J. F. Borzelleca. Div. of Toxicology, Dept. of Pharmacology, Med. Col. of Va., Va. Commonwealth Univ., Richmond, VA 23298

Kepona (10^{-9} M to 10^{-6} M) inhibited a number of basic cellular and biochemical responses. Using the P388D₁ cell line, an *in vitro* cell system was developed utilizing a mosaic of parameters (i.e. cell proliferation, oxygen consumption, phagocytosis, and calcium metabolism) as indicators of cytotoxicity. This cell line has been shown to possess many morphological and functional characteristics of macrophages. Kepona (1×10^{-4} M to 1×10^{-6} M) inhibited cellular proliferation (90 to 20%) and stimulated oxygen consumption (260 to 97%). The ability of the P388D₁ cells to phagocytize opsonized sheep red blood cells was initially enhanced followed by a depression over a four hour treatment period. Kepona produced a significant decrease in the size of the mitochondrial exchangeable calcium pool while increasing the efflux rate constant of that pool. The effects of Kepona on energy metabolism and calcium distribution may be facets of cellular events related to the observed *in vivo* toxicity. (Supported in part by EPA grant number R-80470101.)

BRANCHED CHAIN AMINO ACID TRANSFERASE (BATASE) ACTIVITY IN SELECTED MURINE TUMOR MODELS. W. Chao*, A.M. Kaplan, and W.L. Banks, Jr., Depts. of Biochem., Microbiology and Surgery Med. Col. of Va., Richmond, Va. 23298.

This study was designed to examine the activity (ACT) of BAtase in four different murine tumors, Lewis lung carcinoma (LL), B₁₆ melanoma (B₁₆), MCA 2182 fibrosarcoma (MCA) and A₂₆ glioma (A₂₆), as well as in selected tissues (liver, muscle, kidney and brain) of the tumor-bearing host. Groups of 10 female C57BL/6J mice were inoculated S.C. on the flank with 5×10^5 trypsinized viable cells from each tumor line. BAtase measurements were carried out on all tissues 18-20 days after the inoculation of the tumor cells. BAtase was assayed in a media containing LEU, mercapto-ethanol, Δ KG, pyridoxal phosphate, and potassium pyrophosphate buffered at pH 8.2. BAtase ACT was expressed as μ m keto LEU formed/gm tissue. The results showed that among the tumors, LL had significantly higher and B₁₆ had significantly lower BAtase ACT than the other tumors. With the host tissues, all organs except the brain in the LL mice showed significantly higher BAtase ACT than the comparable tissues of the control non-tumor bearing mice and there was no difference in the tissues of the MCA mice as compared to those of the control. BAtase, being the first enzyme in the catabolism of branched-chain (BCAA), these data offer indirect evidence that BCAA metabolism might be altered in tumors and the host tissues. (Supported by ACS IN-105D.)

AN INTEGRATION OF RETROGRADE PEROXIDASE AND GOLGI TECHNIQUES FOR THE EVALUATION OF NEURONAL MORPHOGENESIS AND SYNAPTOGENESIS. C.W. Christian, J.T. Povlishock*, Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298

The study of morphogenesis within both the developing and maturing nervous system has long been problematic due in part to the difficulty encountered in the ready and precise recognition of specific nuclear complexes. The present investigation reports a new protocol that minimizes these difficulties. In this current report we consider the maturation of the rat hypoglossal nucleus. To precisely identify this nucleus the tongue musculature of neonatal rats was injected with a 10% solution of horseradish peroxidase (HRP) in a 2% solution of DMSO. After a brief survival the animals were perfused and their brains were serially sectioned on a Vibratome. The serial sections were collected and processed for either the light or electron microscopic visualization of HRP. At the light microscopic level the reaction product was intense and thereby allowed for the ready visualization of the maturing neuronal soma and dendritic appendages. Concomitant Golgi studies confirmed that the morphological features seen with HRP were consistent with those shown with silver impregnation. Of further benefit was the finding that when the adjacent serials were studied at the electron microscopic level, the protein tracer could again be identified and thus a specific hypoglossal neuron could undergo detailed ultrastructural analysis.

COMPARISON OF NUCLEAR NONHISTONE POLYPEPTIDES BY LIMITED PROTEOLYSIS. D. L. Cochran* and K. R. Shelton, Dept. of Biochemistry, Med. Col. of Va., Richmond, VA 23298

Neither the structure nor the function of most nuclear nonhistone proteins is well understood. Properties of several chicken erythrocyte nuclear polypeptides including abundance, solubility and ease of polymer formation indicate that these polypeptides may have a structural role in the cell nucleus. In a further effort to characterize these polypeptides, nuclear nonhistone proteins were isolated and subjected to limited proteolysis by incubation with each of three enzymes: papain, chymotrypsin and staphylococcus aureus protease. The polypeptides yielded several abundant common peptide fragments as well as lesser amounts of identical and nonidentical fragments. These results demonstrate that the purified avian erythrocyte nuclear nonhistone polypeptides share amino acid sequences. The extensive sequence homology indicate that these nonhistone polypeptides have related structural roles. (Work supported by grant number CA15923, awarded by the National Cancer Institute, DHEW.)

UNOXIDIZED AND OXIDIZED ISOPROTERENOL-INDUCED MYOCARDIAL CALCIUM CHANGES AND PATHOLOGY. T.W. COFFEY*, J.L. Poland, F.O.W. Shieff*, and K.C. Corley, Dept. of Surgery, Med. Col. of Va., Richmond, VA. 23298

Unoxidized isoproterenol (UIISO) produces subendocardial pathology which has been ascribed to hypoxia rendered by an inadequate coronary blood flow to suffice the chronotropic and inotropic effects of UIISO. However, oxidized isoproterenol (OISO) produces more severe pathological changes than UIISO. Some data suggest that an isoproterenol-induced elevation of intracellular calcium (Ca) is also involved in myocardial pathology. The present study investigates in the rat the mechanism by which UIISO- and OISO- induced Ca changes may mediate myocardial pathology. The effects of UIISO and OISO (50 mg/kg s.c.) on total myocardial Ca, subendocardial and subepicardial sarcoplasmic reticulum (SR) uptake velocity and capacity were studied when injected alone and simultaneously with propranolol (β -adrenergic antagonist) or verapamil (Ca antagonist). Both UIISO- and OISO- induced increased total Ca and differentially affected SR Ca uptake velocity between the subendocardial and subepicardial. While the OISO changes were reduced by propranolol or verapamil, only verapamil blocked OISO changes. Although isoproterenol toxicity may be Ca mediated via β -receptors, the oxidized products of isoproterenol may produce their effects via Ca mediation at some site other than the β -receptor (Aided by NIH grant HE 13454).

SPECTROPHOTOMETRIC ABSORBANCES OF BLOOD PLASMA IN NUTRITION-PROFILES. G. Colmano, Veterinary Medicine, VPI & SU, Blacksburg, VA 24061

Blood plasma of animals has absorption peaks in the 180-220 nm region for dipeptide bonds, at 280 nm for aromatic amino acid residues, and at 414 nm for porphyrin derivatives from hemoprotein of destroyed erythrocytes. The ratios of these absorption peaks have empirically indicated a close relationship with different nutritional protein levels. This relationship has been followed in several animal species under different experimental conditions. Rats on a protein deficient diet decreased the dipeptide bonds and the aromatic amino acid residues of proteins, and increased hemoproteins. Fifth generation mice and quail with chronic mercury poisoning exhibited a higher hemoprotein at 414 nm. Mice with growing sarcoma 180 ascitic tumors had changes in protein concentration in blood plasma and ascitic fluid that were followed during the development of the tumor to compare them to those of mice rejecting the tumor. Optimal energy utilization by feedlot steers separated into 4 groups of protein supplementation, and lactating cows on 2 levels of protein supplementation became clearly differentiated from the level of protein utilization calculated on the spectral absorbances at 205 nm, 278 nm and 414 nm. These results indicated that the spectrophotometric absorption technique presents a new and promising method for detecting levels of nutritional proteins in blood plasma.

BACTERIOSTASIS OF STAPHYLOCOCCUS AUREUS BY POSITIVE DIRECT CURRENT ACTIVATION OF METAL IONS IN MONOMOLECULAR FILMS IN INTRAMEDULLARY PINS. G. Colmano, S. S. Edwards, and S. D. Barranco*, Veterinary Medicine, VPI & SU, Blacksburg, VA 24061; Montgomery County Orthopedic Associates, Blacksburg, VA 24060

When solid silver pins were contaminated with -3000 Staphylococcus aureus and placed either into agar or broth, or inserted into the femurs of rabbits, it was found that all 3000 bacteria could be eliminated by applying one hour of 12 A positive direct current to the pins. As silver was too soft for practical use, silver electroplated stainless steel pins, or stainless steel pins coated with 100 monomolecular layers of silver stearate were substituted and achieved the same result. At this point, many different metal stearates were tried and it was determined that an equimolecular combination of silver and cerium stearate gave the best and most consistent bacteriocidal results. In the dog, while we could not induce an active form of osteomyelitis, we were able to markedly reduce the bacterial infection in the current treated ulnas as compared to the untreated ulnas. However, while the mechanisms underlying the bacteriocidal effect are still under investigation, this approach provides a useful method in the therapy of osteomyelitis in domestic animals.

ABSORPTION SPECTRA OF BLOOD PLASMA AND ASCITIC FLUID FROM MICE BEARING 5-180 ASCITIC TUMOR CELLS. G. Colmano and G. G. Schurig*, Veterinary Medicine, VPI & SU, Blacksburg, VA 24061

Absorption spectra of blood plasma samples from random bred Dublin (ICR) mice were compared before and after intraperitoneal injection with viable Sarcoma 180 cells. Also, spectra of ascitic fluid, tapped from the peritoneal cavity containing the ascitic tumor, were compared. Absorption spectra scans of blood plasma and ascitic fluid from 180 nm to 700 nm had three major peaks at 188 nm, 278 nm, and 414 nm, indicating that blood plasma and ascitic fluid contained the same basic components. However, the ratios of the peaks revealed changes from the first to the third bleeding. These changes profiled the development of the tumor. Preliminary findings indicated that our technique is able to detect some characteristic changes in blood plasma and ascitic fluid of mice during the development of the tumor. In the animals capable of rejecting the tumor, the observed changes need to be studied further.

SCANNING AND TRANSMISSION ELECTRON MICROSCOPY OF DECIDUAGENESIS IN THE IMMATURE RAT. S.S. Craig* and W. P. Jollie, Dept. of Anatomy, Med. Col. of Va., Richmond, VA. 23298

Uteri of sexually immature rats are capable of responding to ovarian steroid hormones and of undergoing decidualization, an endometrial transformation which normally occurs in the adult rat during implantation. Decidualization can be induced experimentally in prepubertal rats which have been injected with ovarian hormones on a regimen shown to support implantation. Nineteen-day-old rats were bilaterally ovariectomized, and received 8 daily subcutaneous injections of progesterone and a single injection of 17- β estradiol on day 4 of progesterone treatment. To induce decidualization, sesame oil was injected into the right uterine lumen on day 5. The left uterus served as a control. The rats were killed on day 9, and uteri were removed, weighed and processed for electron microscopy.

Because of decidual growth, the right uteri increased in weight between 200 and 900 percent. With scanning electron microscopy, the luminal surfaces of epithelial cells of the control uteri were covered with abundant long microvilli; the epithelial cells of decidual uteri had increased in width or diameter and their surfaces contained fewer and shorter microvilli. With transmission electron microscopy, control epithelial cells were columnar and stromal cells resembled active fibroblasts. Luminal epithelial cells of the decidualized horn were squamous; and stromal cells exhibited features characteristic of decidual cells in adult animals.

PERSONALITY PROFILES OF ACUTE CARE AND NON-ACUTE CARE NURSES. L.J. Crosby, School of Nursing, Univ. of Va. Charlottesville, Va. 22901

This study investigated the question: are there significant differences in personality profile scores (PPS), of nurses who select and subsequently practice for one yr. within acute care and non-acute care hospital units? The purpose was to develop a personality profile for each of these two groups. N=85 newly graduated nurses, X age 24yrs. Educ. prep., 67 B.S.N., 12 A.D.N. and 5 Diploma in Nursing. Subjects self-selected acute care or non-acute care work areas as first professional experience. During pre-employment orientation, subjects were tested utilizing the Adjective Check List (ACL) and California Psychological Inventory (CPI). Following one year of practice, subjects were retested. Mean scores of the 48 ACL and CPI profile traits were analyzed for between/within group differences and similarities. Subjects who remained within practice areas for one year were utilized to develop a composite profile of each group, N=38. Stat. significant between group differences were identified prior to and following one year of nursing practice. Based on this study, acute care nurses can be characterized as self-assured, dominant, adventurous individuals who avoid routine and seek out complex disordered environments. Autonomy is preferred within personal and professional situations. Non-acute care nurses are self-assured, stable, practical individuals who tend to avoid risk-taking situations. Close group affiliation is preferred in personal and professional situations.

A NEW PROTOCOL FOR THE PHYSIOLOGICAL AND MORPHOLOGICAL EVALUATION OF THE PIAL VASCULATURE AND ITS APPLICATION TO THE STUDY OF HYPERTENSION. W.D. Dietrich*, E.P. Wei*, J.T. Povlishock* and H.A. Kontos*, Depts. of Anatomy and Medicine, Medical College of Virginia, Richmond, Virginia 23298.

Scanning and transmission electron microscopy in conjunction with physiological assessment were employed in the study of the pial vasculature following acute hypertension. Through such a regimen we have correlated the hypertensive functional alterations of the pial arterioles with those morphological alterations observed therein. To this end, the pial vasculature of 20 cats was prepared for direct visualization via the insertion of a cranial window, and then systemic hypertension was produced by angiotensin infusion. When arterial blood pressure was elevated above 220mmHg for 15 minutes, the vessels displayed profound vasodilation. Following completion of the functional studies the physiologically monitored vessels were identified with the use of a map previously drawn through the cranial window demonstrating the course of the vessels. These same vessels were then processed for routine scanning and transmission electron microscopy. Scanning electron microscopy of pial arterioles demonstrated endothelial craters and balloons which corresponded to the endothelial surface indentations and cytoplasmic blebs recognized in these same vessels with transmission electron microscopy. The results of this study demonstrate that via the use of rigorous morphophysiological analyses, the morphological correlates of physiological vascular dysfunction can be identified.

EFFECT OF PROLONGED DIET RESTRICTION IN THE SPONTANEOUSLY DIABETIC MOUSE. B.A. Dore* and S.R. Webb, Biology Dept. Virginia Commonwealth Univ., Richmond, Va. 23284

The autosomal recessive gene, db, causes a spontaneous diabetes-like disease in the mouse strain C57BL/Ks. The hyperphagic mice became obese and exhibited hyperglycemia, glucose intolerance, glycosuria, and polyuria. Homozygous diabetic (db/db) and normal (+/+) mice were examined in this study. All mice were 25 day old males weighing approx. 10 g. The +/+ mice and one group of db/db mice were allowed food *ad lib*, while daily food allowance was restricted in another group of db/db mice. Ad *lib* db/db mice quickly became obese and developed all expected signs of diabetes. Obesity was prevented in the diet restricted db/db mice which helped normalize blood glucose and insulin levels and glucose intolerance. Obese db/db mice died with diabetes at 1-6 months of age; +/+ and lean db/db mice were examined for over 2 years. Comparisons were made on the weight of the spleen, thymus, pancreas, heart, kidneys, liver, testes, and inguinal fat pads; also compared were plasma and tissue neutral lipids and blood cell parameters. Diet restriction prevented some anatomical and physiological changes associated with the obese db/db mouse but had little effect on others.

EVIDENCE FOR THE RELEASE OF ENKEPHALINS AND OTHER ENDOGENOUS OPIATES BY MORPHINE. William L. Dewey, Department of Pharmacology, Medical College of Virginia, Richmond, VA 23298.

Peptides with opiate like activities have been isolated from the brain and pituitary glands of many animal species. We now present evidence that the narcotic analgesic, morphine causes a release of a substance(s) with opiate like effects into the cerebrospinal fluid. The purpose of these experiments was to determine if these released endogenous opiates were involved in the mechanism of action of morphine. A number of experiments in spinal mice clearly showed that information from the brain, which is considered to be the site of action of morphine, to the lower levels of the spinal cord is carried via CSF and is essential for inhibition of the tail-flick response. CSF taken from rabbits had opiate like activity in a number of *in vitro* and *in vivo* test systems. The opiate like activity of rabbit CSF was significantly increased 60 mins. after the injection of morphine. Radiotracer experiments demonstrated that the level of morphine in CSF was less than minimally active concentrations in these test systems ruling out the possibility that morphine was producing these effects. We found that morphine did not alter the opiate like activity of mouse brain extracts. These data indicate that the opiate like materials released from brain are very rapidly replaced. (Supported by USPHS grants DA-01647, DA-00326 and DA-00490).

POSTNATAL GROWTH RETARDATION AND BEHAVIORAL EFFECTS OF PHENOCYCLIDINE ADMINISTRATION IN THE RAT. Stephen H. Javidine* and R.L. Jordan, Department of Anatomy, Medical College of Virginia, Virginia Commonwealth University, Richmond, Virginia 23298.

Female Sprague-Dawley rats received 10 mg/kg injections (i.p.) of phenocyclidine (PCP) once daily from day 6-15 of pregnancy and were allowed to deliver normally. At birth litters were culled to 8 pups and divided into 3 groups. 3S litters were reared by PCP-treated dams, 3 litters by saline-injected control animals, and 3 litters by untreated dams. Control animals were fostered to PCP-treated dams, untreated dams and saline-treated dams in a similar fashion. Pups were weighed and examined daily on three behavioral development tests: development of locomotion, development of climbing skills, and righting time.

Prenatal drug exposure had a greater effect than postnatal care. Pups exposed to PCP and reared by a PCP-treated dam gained significantly less weight during the neonatal period than control pups and took significantly longer to develop locomotor and climbing skills. Animals exposed to PCP but reared by control dams also gained significantly less weight and were slower than controls on skill development, but the retardation was not as severe. Pups not exposed to PCP but reared by a PCP-treated dam showed a slight retardation in weight gain and skill acquisition.

(Supported by the Grants-In-Aid Program for Faculty of Virginia Commonwealth University and an A.D. Williams Summer Fellowship).

SITES FOR CHLORDECON (KEPONE®) NEUROTOXICITY IN RAT BRAIN. David W. End*, Richard A. Carchman*, Richard Ameen*, Edward L. Carmine* and William L. Dewey. Dept. of Pharmacology, Med. Col. of Va., Richmond, VA 23298

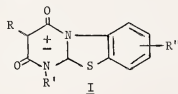
The pesticide chlordane (Kepone®) produces pronounced neurological effects in man and laboratory animals. We investigated the mechanism of these effects in rats. Concentrations of chlordane from 10-8 to 10-5M produced a dose dependent inhibition of oxygen consumption and respiration dependent Ca^{++} sequestration in mitochondria isolated from rat brain. These effects of chlordane were localized to an inhibition of the coupling reactions of oxidative phosphorylation and were observed following *in vivo* administrations of tremorigenic (40 mg/kg, p.o.) doses of chlordane. Chlordane's inhibition of brain mitochondrial function led to elevations of cytosolic Ca^{++} in synaptosomes (pinched off nerve endings) which blocked the influx of extracellular Ca^{++} (the normal signal for neurotransmission) while triggering a marked release of the neurotransmitters dopamine, serotonin, and norepinephrine. Comparison of subcellular ^{14}C -chlordane concentrations following *in vivo* administration to tissue concentrations achieved *in vitro*, revealed that a 5 x 10⁻⁶M chlordane concentration approximated a neurotoxic tissue concentration of this neurotoxic substance. (Supported in part by EPA 804701010, DA-01647 and SM-1722901).

CROSS-CIRCULATION STUDIES ON THE SITE OF MORPHINE ANALGESIC ACTION IN THE BRAIN. Tzu-Ching Fu*, Stephen P. Halenda* and William L. Dewey. Dept. of Pharmacology, Medical College of Virginia, Richmond, VA 23298.

The mechanism of action of morphine and other narcotic analgesics has not been fully elucidated. Previous work from this laboratory indicates that morphine causes the release of endogenous opiates which may be involved in its mechanism of analgesic activity. The purpose of these experiments was to determine the location of this release in the rat brain. Lightly pentobarbital-anesthetized rats were cross-cannulated, blood flowing from the donor body to the recipient head via the common carotid artery and returning via the external jugular vein. A good blood flow in the connected cannula was confirmed by pulsation and by saline infusion which was quickly washed down in the cannula. Antinociception was measured by the tail-flick test, control latencies being approximately 3 sec. 10 mg/kg morphine sulfate (MS) injected into the jugular cannula produced tail-flick latencies of greater than 10 sec. in the donor within 5 min., while no effect was seen in the recipient up to 60 min. after injection. 5 mg/kg MS injected into the carotid cannula towards the recipient head did not increase tail-flick latencies in either the recipient or the donor by 30 min. after injection. These results suggest that in rats the essential area for MS antinociception is not in structures above the midbrain. (Supported by DA-00326, DA-00490 and DA-01647).

NOVEL MESOIONIC PURINONE ANALOGS AS INHIBITORS OF CYCLIC-AMP PHOSPHODIESTERASE. J. J. Gaines*, R. A. Glennon* and M. E. Rogers*. Dept. of Pharmaceutical Chemistry, MCV/VCU, Richmond, Va. 23298

Various purinones, such as theophylline, inhibit cyclic 3',5'-adenosine monophosphate (cyclic-AMP) phosphodiesterase, an effect believed to be responsible, in part, for their clinical utility. Structural modification of such purinones has led to more potent and more selective inhibitors. Recently, we reported that mesoionic purinones are also active as inhibitors of cyclic-AMP phosphodiesterase. Mesoionic purinones constitute a virtually unknown class of heterocyclic compounds which warrant further investigation. We now wish to report the synthesis and evaluation of a series of benz-fused mesoionic xanthine analogs (I) which appear to be somewhat more active than their previously reported bi-cyclic counterparts.



Supported in part by NIH grant HL-22566.

VASCULAR REACTIVITY IN CADMIUM-TREATED RATS. J. L. Hart. Biology Dept., George Mason Univ., Fairfax, VA 22030

The responsiveness of helically-cut aortic strips from female Long-Evans hooded rats to epinephrine (EPI), KCl, and angiotensin II (ANG) was determined 1, 2, 3, and 6 months after beginning cadmium (Cd) treatment (5ppm in drinking water). No cadmium was added to the water of controls. Systolic blood pressures (tail cuff method under pentobarbital anesthesia) and weights were measured, and there were no differences between controls and Cd rats at any of the test periods. The mean initial weight (\pm SE) of the 60 rats was 85.7 ± 9.3 g, and age was about 5 weeks. Complete dose-response curves were done on 5 or 6 aortic strips from each group at each test period. Both control and Cd rats showed similar age-related changes in response during the 6 month study; however at all 4 test periods the maximum isometric tension development (g/cm^2) of the Cd strips to EPI was significantly less ($p < .05$) than controls, with reductions ranging from 20 to 28%. Tension development of Cd strips to KCl and ANG were also consistently reduced, by about 20%, but the reductions were significant for KCl only at 2 and 6 months, and for ANG at 3 months. Previous studies involving acute Cd exposure found that Cd interferes with vascular smooth muscle contraction, an effect that was attributed to the ability of Cd to limit calcium ion movement and/or availability. The present studies demonstrate that chronic Cd ingestion also interferes with vascular contractility. (Supported by GMU grant #7010-2124.)

VASCULARIZATION OF THE CORPUS LUTEUM. S. D. Gaede*, and S. L. Quattropani*. Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298.

The vascularization of developing corpora lutea has been studied by light and electron microscopy in cycling adult and superovulated immature rats. Ovarian follicles examined by light microscopy exhibit infoldings of the granulosa layer and adjacent thecal tissue. Adjacent to the basal lamina of the follicle, a layer of light-staining thecal cells is identified. Ultrastructurally, these cells exhibit a paucity of organelles. The granulosa cells of these follicles are in a pseudostratified configuration. Between them are numerous extravasated erythrocytes. In some large follicles, capillaries can be seen by light microscopy between the granulosa cells in the periphery of the follicle. While numerous mitotic figures have been identified in the thecal and granulosa tissue, these are generally associated with fibroblasts and granulosa cells.

Approximately one hour after ovulation, numerous capillaries can be seen in the peripheral region of the corpus luteum. The capillaries are thin walled with numerous large fenestrae. At these fenestrae, the basal lamina is continuous and blood platelets frequently appear to form plugs. Extravasated erythrocytes are seen between lutein cells and within the remains of the antral cavity.

ULTRASTRUCTURAL AND BIOCHEMICAL ALTERATIONS IN DESCOMET'S MEMBRANES FROM BUPHTHALMIC RABBITS. T. M. Harris. Dept. of Anatomy, R. F. Diegelmann, Dept. of Surgery and L. B. Sheppard, Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298

Fure samples of Descemet's membranes (DM) were obtained from six buphtalmic rabbits (Jackson Laboratories, Bar Harbor, Me.) and 24 New Zealand white rabbits. Samples from three of the buphtalmic DM's were prepared for transmission electron microscopy and the remainder were pooled according to the source, hydrolyzed in 6N HCl, and prepared for analysis on a JEOU-5 AM Amino Acid Analyzer. Electron micrographs of DM from each of the three buphtalmic rabbits showed localized deposits of dense fibrillar material. The fibrils were approximately 52 nm in diameter and lacked any specific banding pattern. The amount of fibrillar material varied among the three animals, but in all cases, it was interspersed between zones of non-fibrillar, normal appearing DM. The amino acid analysis of the pooled buphtalmic membranes showed significantly increased levels of 3-OH proline compared to normal DM. These studies suggest that the deposition of the electron dense material coincides with the episodes of increased intracocular pressure that characterize advanced buphtalmia. The altered amino acid composition of the buphtalmic DM further suggests that the dense material represents a collagenous substance with a modified 3-OH proline content. (Aided by NIH Grant 1 R01 EY 02991).

A FINE STRUCTURAL COMPARISON OF THE PINEAL GLAND OF THE GENETICALLY MICROPHthalmic GOLDEN HAMSTER WITH THE NORMAL. M. E. Hill*, C. G. Jackson*, J. T. Fovellshock*. Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298

In order to assess the correlation between the pineal gland and the intact visual system, the present investigation was initiated to study pineal morphology in both microphthalmic and normal hamsters. To this end normal and genetically microphthalmic hamsters were processed for both routine light and electron microscopy. The morphological features of the control animals appeared unremarkable and both the pinealocytes and glial cells contained a complement of cellular organelles consistent with those previously described by others. In the genetically microphthalmic animals, however, conspicuous dilation of both the pinealocyte perinuclear cisterns and their smooth endoplasmic reticula was observed. Despite these alterations, all other pinealocyte organelles appeared unaltered. Although the dilated perinuclear cisterns and smooth endoplasmic reticula were the only observed cellular abnormalities, their occurrence was extremely consistent. The functional correlates of these cellular alterations remains to be assessed. However, an initial investigation on the role of these cellular perturbations in the genesis of gonadotropic interaction has been initiated. The results of these studies will be discussed.

COMPARISON OF SOMATOMEDIN-C AND A GROWTH HORMONE FRAGMENT WITH RESPECT TO RECEPTOR INTERACTION AND CERTAIN BIOACTIVITIES. J.R. Hubbard and J.P. Libertini*, Department of Biochemistry, Medical College of Virginia, Richmond, VA 23298 USA

Growth hormone (GH) is believed to increase cartilage growth and metabolism via secondary substances called somatomedins (SM). Thus while GH has no detectable effect on cartilage *in vitro*, GH-dependent SM directly stimulates chondrocyte growth, proliferation and synthesis of matrix. We now report that a growth promoting fragment of GH, A-II (bov 96-133), has direct SM-like effects on cartilage and fibroblasts. Using a previously described SM assay, we found that A-II significantly increased proteoglycan sulfation in cultured human fibroblasts (WI-38 strain). This stimulation was log-dose dependent with maximal stimulation noted at 10^{-8} M. In the presence of hypo-GH serum both A-II and SM-C enhanced sulfation of embryonic chick cartilage *in vitro*. Maximal stimulation was noted with 5×10^{-11} M A-II and with 10^{-9} M SM-C. These substances had lower activity in the absence of this serum. A-II and SM-C also stimulated rat cartilage sulfation. In this system, serum was not required and maximal stimulation was noted at 10^{-7} M A-II or SM-C. Interestingly, A-II and SM-C competed for receptor(s) on both human placental membranes and chondrocytes. Thus, we are the first to show that a GH fragment (unlike the parent molecule) has SM-like bioactivities. The mechanism of GH-dependent SM generation is unknown. Our results invite speculation that certain SM(s) may be produced *in vivo* via proteolytic cleavage of GH. (Supported by NIH Grant AM-16457)

DEMONSTRATION OF A CARTILAGE PROTEASE ACTIVITY WHICH IS GROWTH HORMONE DEPENDENT. J.R. Hubbard, N.O. Owens* and J.P. Libertini*, Departments of Biochemistry and Anatomy, Medical College of Virginia, Richmond, Virginia 23298

Several *in vivo* effects of growth hormone (GH) on growth and metabolism of cartilage have been well documented. We now report the GH-dependent stimulation of a protease activity in cartilage. This activity was assessed by digestion of artificial gelatin membranes by slices of rat costal cartilage. The membranes were stained to visualize digested areas and photographed. The negatives were scanned at 540 nm to quantify the extent of digestion. The enzymatic nature of the reaction was inferred from our observations that digestion a) increased with longer incubation times, b) was pH-dependent and had an optimum of about 4.0, and c) was temperature-dependent, showing high activity at 37° and low activity at 100°. Cartilage protease activity of hypox (hx) rats given 4 daily injections of GH (total dose 1.5 ug-500 ug) showed a log-dose dependent increase over hx controls. 500 ug GH increased activity 3 to 4-fold. Specific activity appeared to be inversely proportional to rat age (or wt). This observation may relate to decreased GH-secretion and/or to decreased tissue responsiveness. This is the first demonstration of an acid protease activity in cartilage which is GH-dependent. This relationship may lend new insight regarding GH's action and mechanism. In addition, this system has potential use as a novel GH bioassay. (Supported in part by NIH Grant AM-16457)

FREEZE-FRACTURE STUDIES OF RAT UTERINE EPITHELIUM, M.J. Iwanik and W.P. Jollie, Dept. of Anatomy, Med. Coll. of Va., Va. Comm. Univ., Richmond, Va. 23298

In order to clarify the effects of estrogen on the cell membranes of its target tissues, the freeze-fracture technique has been applied to the rat uterus during the estrous phase of the estrus cycle.

Uteri were fixed in 2.5% phosphate buffered glutaraldehyde, pH 7.4, cryoprotected in 30% buffered glycerol and frozen in Freon 12 cooled with liquid nitrogen. Specimens were fractured and replicated in a Polaroid Freeze Etch Unit at a stage temperature of -120°C and a vacuum better than 10^{-6} Torr. Replicas were cleaned in Clorox for 24 hours. The epithelium was identified by the presence of microvilli. The plasma membrane protoplasmic face (PP) exhibits more intramembranous particles (IMP) than the extracellular face. Numerous subparticles were observed frequently in wave-like clusters. The occluding junctions are characteristic of "very tight" epithelia, measuring 0.70 μm in depth and consisting of 9-15 PF ridges. The ridges are more numerous and more compact in the apical third of the junction as compared to the basal two-thirds. Fracture faces of nuclear envelope membrane exhibit IMP, subparticles, and 8-10 nuclear pores per μm^2 . Nuclear pores are circular in shape measuring 0.1 μm in diameter. Investigations are presently underway to determine if the membrane morphology is altered by estrogen withdrawal following ovariectomy.

BEHAVIOR OF MICE AFTER PRE- AND POSTNATAL EXPOSURE TO A PCB, Jan E. Jenkins* Biology Dept., George Mason Univ., Fairfax, VA 22030

Offspring of mice maintained on a diet containing 0, 5 or 100 ppm Aroclor 1254, a PCB, throughout gestation and lactation were maintained after weaning on the same diet to which their mothers were exposed. At 23 days of age half the offspring began 13 days of conditioned avoidance response (CAR) training. Number of correct responses per day, response time per trial and number of jumps during a 20-second inter-trial interval were recorded. At 27 days of age half the offspring were observed in an open field for 30 minutes and number of squares traversed per 5-minute period was recorded.

PCB exposure had no effect on the ability of mice to learn the avoidance response. However, there were significant interactions between diet and day of CAR training for both response time and number of jumps, with decreases in response time over days occurring more rapidly in PCB exposed groups, and with decreases in number of jumps over days occurring more slowly in PCB exposed groups. There was also a significant interaction between diet and length of time in the open field, with decreases in number of squares traversed over time occurring more slowly in PCB exposed groups.

It is noteworthy that these behavioral effects occurred at a chronic, low dose of PCBs which was insufficient to cause morphological symptoms.

A Study of The Inhibitory Effects of Copper In Feline Urinary Obstruction. L.K. Keating*, H.O. Tucker*, and R. T. Friedman, Tucker Animal Hospital, Orange, Va. 22960 and Dept. of Biology, Mary Washington College, Fredericksburg, Va. 22401.

Placement of a copper coil into the bladder of 21 male cats with urinary obstruction over a 5 year period resulted in alleviating the symptoms and preventing recurrence of the obstruction. Experiments carried out on copper balance in two groups of cats, coil implant(C₂) and no coil(N₂), support the hypothesis that with the coil in place excess copper is excreted in the urine in amounts that approximate that released by the coil. Additional studies were carried out on four normal cats, two with coil and stone implants (CS₂) and two with stone implants(S₂). After six weeks, in the (S₂) cats, the stone or sediment was present and gross pathology of the bladder was observed in one case, while on the (CS₂) cats, the stone had dissolved, no pathological changes were seen and urinary copper values were elevated suggesting that copper acts not only to inhibit stone formation but to dissolve existing material.

ISOLATION OF A MACROPHAGE CHEMOKINETIC FACTOR FROM CULTURE MEDIA CONDITIONED BY NEOPLASMIC CELLS. R. D. Lane*, and M. J. Snodgrass, Dept. of Anatomy, Med. Coll. of Va., Richmond, Va. 23298

Cultured neoplastic cells have been shown to release a 15,000 dalton molecule that is a chemotactic (direction) for activated macrophages. Time lapse cinematography indicated that media conditioned by neoplastic cells was chemokinetic (rate) for activated macrophages. One purpose of our investigation was to develop an assay for readily quantitating this chemokinetic effect. A modified macrophage inhibition type of assay was found to be suitable for this purpose.

Peritoneal exudate cells from C57BL/6 mice injected 17 days previously with *Corynebacterium parvum* were used as our source of activated macrophages. The assay involved measuring the distance these cells traveled down the length of capillary tubes immersed in various conditioned culture media. Our results showed the distance traveled by activated macrophages in Lewis lung carcinoma conditioned media was 2.5X greater than the distance traveled by these cells in mouse embryo fibroblast conditioned media. To determine the molecular size of chemokinetic factor the Lewis lung conditioned media was fractionated on a Sephadex G-100 column. Each fraction was then tested for chemokinetic activity with our assay. The chemokinetic factor was found to be in excess of 10⁵ daltons.

DIFFERENTIAL SENSITIVITY OF MACROPHAGES TO TUMOR PROMOTERS AND EPIDERMAL GROWTH FACTOR. D. L. Laskin*, F. K. Kessler*, and R. A. Carchman*. Department of Pharmacology, Med. Col. of Va., Richmond, Va., 23298

The effects of 12-¹²⁵I-tetradecanoyl-phorbol-13-acetate (TPA) on phagocytosis of opsonized (OPS) and unopsonized (UNOP) chromated sheep red blood cells (SRBC) by mouse peritoneal macrophages (MΦ) recruited either by thioglycollate (TG) or the pyran copolymer, methyl vinyl ether (MVE), and a transformed cell line, P388D1 produced varying TPA, in the range of 10^{-9} to 10^{-7} M, produced a dose related stimulation (180%) of phagocytosis of both OPS and UNOP SRBC in P388D1 cells, and of UNOP SRBC in TG and MVE cells (150%). Although low concentrations of TPA (10^{-9} M) produced a 130% stimulation of phagocytosis of OPS SRBC in the peritoneal MΦ, higher concentrations (10^{-7} M) produced a 50% inhibition. This inhibition was due to a direct effect on the membrane and/or receptor properties of the cells, as evidenced in scanning electron micrographs, and not to a loss in cell number or viability. With a series of macrocyclic diterpenes, we found a correlation between their ability to modulate phagocytosis and their potencies as tumor promoters. Epidermal Growth Factor (EGF) which shares many effects with TPA, produced a dose related stimulation of phagocytosis of UNOP SRBC in all three cell types (160%) and of OPS SRBC in P388D1 cells (180%) Unlike TPA, EGF had no effect on TG or MVE cells. These findings provide additional evidence that tumor promoters exert highly pleiotropic effects on cell surface functions.

AFFERENT CONNECTIONS OF THE CLARE-BISHOP (CB) AREA IN THE CAT BRAIN. A.J. McGrath, Jr., G.R. Leichnetz*, and J. Astruc*. Dept. of Anatomy, Med. Col. of Va., Richmond, Va., 23298

The Clare-Bishop (CB) area bears the names of the investigators who first (1954) recognized a region located primarily on the lateral aspect of the middle suprasylvian gyrus of the cat cortex and which electrophysiologically appeared to be involved in visual functions. More recent investigations (Kennedy and Magnin, 1977; Spear and Baumann, 1979) of the CB area have supported its role in visual and/or oculomotor functions. Anatomical studies were initiated to ascertain the afferent connections of this cortical area. Results based on HRP studies (BDHC and TMB, Mesulam) indicate that CB receives corticocortical and subcortical projections. Most notably, ipsilateral areas 17, 18, and 19 as well as the contralateral CB area project to CB. Prominent subcortical projection sites include the basal telencephalon (mainly the claustrum) and the diencephalon (the ventral anterior, intralaminar nuclei, LP-Pulvinar complex, posterior nucleus and the dorsal lateral geniculate nucleus). The data from this study appear to provide an anatomical substratum for a possible role of the Clare-Bishop area in visual and/or oculomotor functions.

MAGNESIUM AS A MODULATOR OF CONTRACTILITY IN VASCULAR SMOOTH MUSCLE. R.S. Morganland*, G.D. Ford*, Dept. of Physiology, Med. Col. of Va., Richmond, Va., 23298.

The regulation of vascular smooth muscle (VSM) contractility has been of interest due to its role in blood pressure and hypertension. Many studies have reported changes in VSM response to physiological agonist under varying ionic conditions. One of the most actively studied constituents of these ionic conditions has been extracellular magnesium (Mg^{2+}). Assuming changes in extracellular Mg^{2+} may reflect changes in intracellular Mg^{2+} , this study was carried out to determine if there was a Mg^{2+} effect on the intracellular contractile apparatus, actomyosin (AM). Since VSM contraction is the product of a Ca^{2+} -activated AM ATPase and believed to be regulated thru a calcium-sensitive myosin light chain phosphorylation system, the influence of free Mg^{2+} levels on Ca^{2+} -activated AM ATPase activity, sol-gel transformation of AM, total phosphorylation of AM, and phosphorylation of the myosin light chain kinase were monitored. The results of these experiments showed a definite Mg^{2+} dependence of the Ca^{2+} -activated AM ATPase and total phosphorylation with optimums at 5mM Mg^{2+} . The rate of and extent of sol-gel transformation as well as rate of total phosphorylation were augmented by increasing Mg^{2+} levels. However phosphorylation of the myosin light chain did not correlate with changes in Mg^{2+} levels. This data strongly suggests an integral role of Mg^{2+} in the regulation of VSM contractility entailing more than just the myosin light chain phosphorylation system.

A MORPHOLOGICAL STUDY OF ARACHNOID VILLI IN THE BABOON. Levine, J.E., Povlishock, J.T., Sullivan, H.G., Becker, D.F.* Depts. of Anatomy and Neurosurgery, Med. Coll. of Va., Richmond, Va. 23298

Defective cerebrospinal fluid (CSF) absorption remains an important clinical problem. Although most investigators agree that arachnoid villi are the major location of the absorptive process, the mechanism remains elusive.

To better examine this phenomenon we have initiated a pilot study in a physiologically monitored and controlled baboon model. In this animal, factors influencing CSF absorption such as the intracranial and sagittal sinus pressures are monitored and held within strict limits. Concomitant with this physiological control, the animals are perfused transcardially with aldehydes and processed for scanning (SEM) and transmission (TEM) electron microscopy. Via SEM the villi appear composed of continuous endothelia; their surface morphology demonstrating an irregular and invaginated contour reminiscent of vacuolization. TEM confirms and supplements the SEM by demonstrating conspicuous endothelial vacuoles; additionally micropinocytotic vesicles are seen. It is anticipated that future studies using tracers and modification of pressure gradients may elucidate the role these arachnoid endothelial features serve in CSF absorption.

AN ULTRASTRUCTURAL STUDY OF DEVELOPING MOUSE FETAL LIVER. E.S. Medlock*, J.L. Haar*, Dept. of Anatomy, Med. Col. of Va., Health Sciences Division, Virginia Commonwealth University, Richmond, Va., 23298

Mouse fetal liver morphology of 10-, 11-, 12-, 14- and 17-day old fetuses was studied utilizing light, transmission and scanning electron microscopy. Localization of endogenous peroxidase was studied using light and transmission electron microscopy. The vasculature of the hepatic primordium was represented by large vessels ($> 20\mu$) with a continuous endothelial lining and small vessels ($4-20\mu$) with a discontinuous endothelial lining. Precursors of hepatic parenchymal and hemopoietic cells (including myelopoietic, thrombopoietic and erythropoietic cells) composed the bulk of the liver substance. Parenchymal precursor cells were identified by the accumulation of lipid, glycogen and membrane bound dense core vesicles. Scanning microscopy has shown a correlated increase in microvillous projections on the lateral cell margins of parenchymal precursors with an increase in gestational age. Myelopoietic precursors exhibited a positive peroxidase reaction in the nuclear envelope, rough endoplasmic reticulum and within membrane bound vesicles. Erythropoietic precursors exhibited a positive peroxidase activity in the form of a diffuse cytoplasmic precipitate. On the basis of the above cytological evidence, a morphological comparison of the above age groups was performed analysing structural changes within the mouse fetal liver.

INTRACELLULAR AND FIELD POTENTIAL RECORDINGS FROM THE RAT OLFACTORY CORTEX. J.W. Hemm* and J.F. Goldberger*, Department of Anatomy, Med. Coll. Va. - VCU, Richmond, Va., 23298.

Bipolar electrical stimulation of either the lateral olfactory tract (LOT) or olfactory bulb (OB) in urethane anesthetized male rats elicited characteristic field potential and single unit responses in the ipsilateral olfactory cortex. An air-dilution olfactometer was also used to deliver 250 msec. pulses of odor to the rats. A tracheal tube and a tube ascending to the choana were inserted. Controlled suction applied to the ascending tube produced an artificial sniff during odor presentations. Recordings were made with beveled, potassium citrate (1.6M) filled micropipettes. 9 cells were recorded in response to LOT stimulation and showed an average latency of 9.1 msec. to spike initiation. 2 of the recordings were intracellular and had latencies of 1 and 3 msec. to initiation of the EPSP. 22 cells were recorded in response to OB stimulation and showed an average latency of 12.5 msec. to spike initiation. 5 of the recordings were intracellular and had latencies of 1-5 msec. to initiation of the EPSP. 22 of the total 31 cells were subjected to odor stimulation with 1-carvone (1 part/100). 11 cells were excited, 8 showed no response and 3 cells' responses were equivocal upon odor presentation. Inhibitory responses were never observed extracellularly or intracellularly.

These preliminary results indicate that 50% of olfactory cortex neurons respond with excitation to 1-carvone and that neuronal inhibition is not apparent in the cells studied.

THE ANATOMICAL DISTRIBUTION OF NERVE FIBER DEGENERATION FOLLOWING SINGLE AND MULTIPLE CEREBRAL CONCUSSIONS IN RATS. L. Claire Parsons, R.N., Ph.D., University of Virginia, School of Nursing, McLeod Hall, Charlottesville, VA 22903

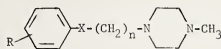
Laboratory rats between 250 and 350 g and following concussion disc implantation were subjected to single and multiple experimental cerebral concussions (ECC) administered through use of a spring coil concussion gun. The force of the blows ranged between 36 and 40 lbs/ft². Criteria for severity of concussion were established utilizing length of seizure, return of corneal reflex and return of motor reflexes. The Fink-Heimer II silver staining method was used to identify nerve fiber and nerve terminal degeneration. A Nissl stain was used to identify cell soma changes and brain stem nuclei. Nerve fibers coursing through coup and contracoup regions of the brain appeared to receive the greatest injury. These regions showed both nerve fiber and nerve terminal degeneration and include the optic nerve, chiasm, tract, transpeduncular nucleus, superior colliculus and lateral geniculate. Cerebroreticular, as well as corpus callosum fibers, showed degeneration but to a lesser extent. Contrary to earlier reports by other investigators, no consistent nerve fiber or cell soma changes were observed to occur in the brain stem reticular formation.

COMPARATIVE ULTRASTRUCTURE OF THE NUTRIA AND GROUND SQUIRREL PINEAL GLANDS. R.L. Salisbury*, R.J. Krieg*, J.F. Povlishock* and H.R. Seibel. Dept. of Anatomy, Med. Col. of Va., Richmond, Virginia 23298.

The pineal glands of the 13-lined ground squirrel (*Citellus tridecemlineatus*) and nutria (*Myocastor coypus*) were examined by electron microscopy. Both glands contained numerous parenchymal cells around which glial, vascular and neural elements resided. The parenchymal cells displayed an eublastic nucleus and a distinct nucleolus. Parenchymal cytoplasmic features common to both animals were mitochondria, Golgi complexes, short profiles of rough and smooth endoplasmic reticulum and occasional dense-cored vesicles (DCV). Lipid droplets, microtubules, multivesicular bodies as well as an electron dense cytosol and few glycogen particles were characteristic of the ground squirrel parenchymal cells. In both species processes of parenchymal origin terminated in bulbous endings. Such endings possessed clear vesicles, mitochondria, and occasional DCV. The ground squirrel vasculature was surrounded by an expanded perivascular space (PVS) in which axons, parenchymal cell terminals and collagen fibers coursed. These vascular elements manifested a fenestrated endothelial lining. The nutria vascular endothelia appeared continuous and glial processes invested the perivascular basal lamina. These findings suggest that the ultrastructural characteristics of the ground squirrel pineal are comparable to those of endocrine tissues, while those of the nutria are reminiscent of brain tissue.

ARALKYLPIPERAZINES AS POTENTIAL DOPAMINE RECEPTOR ANTAGONISTS. J. Salley Jr.* and R. A. Glennon.* Dept. of Pharmaceutical Chemistry, MCV/VCU, Richmond, VA. 23298

Involvement of dopaminergic systems has been implicated in the mechanism of action of neuroleptic agents. Various phenothiazines, thioxanthenes and butyrophenones display a high degree of binding to the postsynaptic receptors of various dopamine (DA) receptor preparations and their ability to inhibit haloperidol binding correlates closely with their clinical potencies. In view of the structural differences among these antagonists, the question arises as to whether activity might reside in a related molecular subfragment. Several aralkylpiperazines, which might be viewed as representative subfragments, were synthesized and evaluated for antagonism employing a rabbit artery DA receptor preparation. Although several of the new compounds act as antagonists, none are as potent as the established neuroleptic agents.



RADIOSENSITIVITY OF MICROVASCULAR GROWTH. M.M. Sholley*, J.L. Montour*, and J.D. Wilson*. Depts. of Anatomy and Radiology, Med. Col. of Va., Richmond, Va. 23298

The radiosensitivity of microvascular growth was studied using a corneal neovascularization model. The left eyes of rats were irradiated, using single doses (500,1000,2000,4000, and 8000 rads) of 45 kVp x-rays. Within 10 minutes after exposure, both corneas were centrally cauterized with silver nitrate. Cauterization elicits a centripetal growth of new vessels from the limbus into the previously avascular cornea. The vessels were perfused with colloidal carbon and the vascular length was measured in corneas fixed at 4 and 7 days. In some cases, ³H-thymidine (³H-Tdr) incorporation at 2 and 4 days was measured on autoradiographs. Dose-response curves based on length appeared to have two components: a sensitive component existed up to 2000 rads, the growth (% of control) having dropped to 68.6 ± 2.9% and to 37.2 ± 1.5% at 4 and 7 days, respectively; whereas, an insensitive component existed up to 8000 rads, where 53.9 ± 1.0% and 29.1 ± 2.0% remained at the same times. The absolute vascular lengths (mm) at both 4 and 7 days were similar at doses from 2000 to 8000 rads. Endothelial ³H-Tdr labeling at 2 days after 2000 rads was reduced to 6.7% of control. The results suggest that cellular proliferation falls off sharply between 1000 and 2000 rads, while a second, more radioresistant, mechanism permits the growth persisting at higher doses. We propose that the radioresistant growth results from migration and redistribution of preexisting endothelial cells from the limbal vessels. (Aided by ACS grant IN-105-C).

THE EFFECTS OF THE DIABETIC STATE ON MORPHINE ACTION IN MICE. Glenn Stuart Simon*, and William L. Dewey. Dept of Pharmacology, Med. Col. of Va., Richmond, VA 23298

Streptozotocin (STZ)-induced diabetes causes a significantly decreased antinociceptive potency of morphine, phenazocine and levorphanol as quantitated by the mouse tail-flick test. This effect is reversed by insulin. The potency of meperidine, methadone and propoxyphene are not altered. Other alterations that cause hyperglycemia or hypoglycemia also cause a significantly decreased or increased (respectively) potency of morphine, phenazocine and levorphanol, but not meperidine, methadone or propoxyphene. The effect of diabetes on morphine potency was confirmed in STZ-diabetic rats and in a strain of genetically diabetic mice. The duration of action of morphine is not altered by STZ-diabetes in the mouse. Levels of ³H are not altered in the brains of STZ-diabetic mice treated with ³H-morphine when compared with controls. Changes in blood glucose levels are accompanied by similar changes in brain-glucose levels and inversely altered plasma insulin levels. These data indicate that diabetes or other conditions that cause altered blood glucose levels can selectively alter the potency of certain narcotics, but not all. An effect at the opiate receptor is not indicated, nor is altered absorption, metabolism, excretion or transport into the brain. (Supported in part by NIH Grants # DA-01647, DA-00490 and GM-07111).

A NOVEL NON-CONTACT METHOD OF MEASURING THREE-DIMENSIONAL SURFACES. Milton Skolaut, Ernest E. Burcher,* and W. Lane Kelly IV.* NASA Langley Research Center, Hampton, VA. 23665

A breadboard optical profilometer has been developed to measure small, three-dimensional surfaces and to find certain specially marked points on these surfaces. The data are presented to the researcher both as a printed contour map and on a cassette tape for input to a larger computer. Although the current breadboard model was designed for a 1.4 cm depth and a 5.5 x 5.5 cm width and length, reasonable increases in depth and large increases in width and length are possible by redesigning the optics and transport system. The breadboard system has been delivered to a dental researcher for a year's field trial of measuring cleft palate casts.

CAN THE NALOXONE RESISTANT COMPONENT OF STRESS-INDUCED ANALGESIA BE ANTAGONIZED. Anne Snow*, Susan M. Tucker*, Stephen P. Halenda* and William L. Dewey. Dept. of Pharmacology, Med. Col. of Va., Richmond, VA 23298

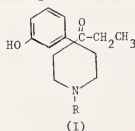
Stress-induced analgesia may be produced by a variety of stressors, including inescapable foot shock, swim stress and immobilization. Reported as possible mediators of this analgesic response are β -endorphin, leucine-enkephalin and methionine-enkephalin. We looked at this phenomenon in terms of the role which endogenous opioids and neurotransmitters have in the genesis of this analgesic response. Rats were exposed to inescapable intermittent foot shock. This stressor produced a 2-3 fold increase in tail-flick latencies. The analgesic response was only partially antagonized by naloxone. To examine the role of neurotransmitter systems in this resistant component, receptor antagonists such as haloperidol, atropine and BCI05 were used. Diazepam and dexamethasone were also used in an effort to prevent stressor-induced analgesia. Neither the receptor antagonists, dexamethasone, nor diazepam were able to antagonize the remaining analgesia. However, atropine and BCI05 did attenuate the analgesic response. In conclusion, the phenomenon of stressor-induced analgesia appears to involve two mechanisms: one which is mediated by endogenous opioid systems and is naloxone reversible; and another unidentified component which is extremely resistant to antagonism and may involve cholinergic and serotonergic pathways. (Supported by USPHS Grants DA-01647, DA-00326 and DA-07027).

FACTORS INFLUENCING ATHLETIC AMENORRHEA. K.A. Sweeney* and D.K. Wakat*, Sch. of Nursing, U.Va., Charlottesville, Va.

Forty-one of 77 college female cross-country runners were subjects in a study to determine factors related to athletic amenorrhea. Athletes were classified as either normal cycling ($n=49$) or oligo/amenorrheic ($n=15$). Comparisons were made of training history, menstrual history, anthropometry and hormone levels. No significant differences between the groups were observed in the following: age (19.6 ± 0.3 vs 19.5 ± 0.3 yrs), weight (119.9 ± 3.7 vs 118.1 ± 2.5 lbs), skinfold thickness sum (48.8 ± 2.3 vs 45.8 ± 2.6 mm), % body fat (17.1 ± 0.5 vs 16.9 ± 0.4), age at which training began (14.0 ± 0.6 vs 13.8 ± 0.5), years in training (4.9 ± 0.5 vs 5.1 ± 0.4), miles run/week (45.7 ± 3.7 vs 52.3 ± 3), and HCT (40.8 ± 0.5 vs 40.0 ± 0.8). Both groups had elevated levels of HGH (18.6 ± 6.5 vs 14.8 ± 3.5 mg/ml), FHR (34.3 ± 2.7 vs 32.9 ± 2.7 mg/ml) but mean values were not significant. A significant difference between the two groups, however, was the onset of menarche (12.9 ± 3 vs 14.2 ± 5 yrs, $p < .05$). More O/As began training at or prior to menarche (15 vs 6 yrs). In addition only 3 of the 18 women runners who were O/As were below the minimum weight for height using Frisch's nomogram (Science 185: 949, 1974). A relationship seems to exist between the onset of training and the onset of menarche. This lack of menses found mainly in those who experienced menarche at a significantly later time cannot be explained by the Frisch hypothesis.

SYNTHESIS AND PHARMACOLOGY OF SOME POTENTIALLY NON-ABUSIVE NARCOTIC ANALGESICS. M. K. Waddie* and M. E. Rogers*. Dept. of Pharmaceutical Chemistry, Med. Col. of Va., Richmond, Va. 23298.

Ketobemidone, a 4-phenylpiperidine analgesic clinically used in Europe, is equivalent to meperidine as an analgesic but is highly addicting. Recent studies have shown that changing the nitrogen methyl to pentyl retains analgesic potency and greatly lessens the physical dependence capacity. We wish to report the synthesis and pharmacology of a series of ketobemidone analogs (I) with varying nitrogen substituents. These compounds were prepared in order to delineate those structural features necessary for analgesic activity and those associated with addiction liability. These compounds have been examined in mice for antinociceptive properties, in rat brain homogenates for receptor affinity, and in morphine dependent monkeys for physical dependence capacity. Several of the newly synthesized compounds appear to merit further investigation as strong non-abusive narcotic analgesics.



THE EFFECTS OF INTRAVENOUS INJECTION OF NALTREXONE ON PITUITARY LH RELEASE IN THE OVARIETOMIZED RAT. Alan R. Swartz*, and J.H. Johnson. Dept. of Anatomy, Med. Coll. of Virginia, Richmond, VA 23298.

Morphine and methadone inhibit pituitary LH release and spontaneous ovulation in the rat (Maughan et al. 1978). Potent narcotic antagonists such as naltrexone selectively inhibit opiate effects on both pituitary LH release and spontaneous ovulation. This study investigated the effects of intravenous injection of naltrexone, which binds to the opiate receptor, on tonic release of pituitary LH in the ovariectomized rat. Fourteen long-term ovariectomized rats (Sprague-Dawley) were anesthetized with Brevital, and cannulae were inserted into the right external jugular vein to approach the right atrium. Seven rats received 1 ml saline i.v. (0.9% heparinized 10 units/ml) while the remaining seven were injected with naltrexone (1 mg in .1 ml) through indwelling cannulae. Whole blood samples (100 μ l in duplicate) were collected for 3 hours at 10 minute intervals from each rat, and blood was assayed for LH by double antibody radioimmunoassay. Saline and naltrexone failed to alter pulsatile rhythms of LH release in all 14 animals. Furthermore, mean levels of LH were not significantly different in the two groups as determined by Student's t test. These results indicate that this dose of naltrexone does not influence LH release, and therefore could be used in attempts to antagonize the effects of narcotics on the release of gonadotropins. (Supported by NIH Grant HD 12165-01).

EFFECTS OF 11-HYDROXY- Δ^9 -TETRAHYDROCANNABINOL ON BRAIN CHOLINERGIC SYSTEMS. Hem L. Tripathi*, Sandra K. Welch*, Ramona J. Winkler* and William L. Dewey. Dept. of Pharmacology, Med. Col. of Va., Richmond, VA 23298

We have studied the effects of 11-hydroxy- Δ^9 -tetrahydrocannabinol (11-OH- Δ^9 -THC) an active metabolite of Δ^9 -THC the predominant constituent of marihuana, on levels and turnover rate of acetylcholine (ACh) and levels of choline (Ch) in various mouse brain regions (medulla-pons, corpus striatum, midbrain, hippocampus and cortex). Doses of 11-OH- Δ^9 -THC of 1, 10 and 30 mg/kg were administered i.p. and after 20 min. 6.4 mCi (80 nmoles/kg) of 3 H-Ch was infused via the tail vein. Groups of 6 to 12 mice were sacrificed at either 2 or 3 min. by microwave irradiation of the head. ACh turnover rate was determined by the biosynthesis ratio method (Schubert et al., J. Neurochem. 16:695, 1969). 11-OH- Δ^9 -THC did not effect the level of ACh in any brain region but showed a dose related decrease in turnover rate of ACh in the hippocampus region. The difference was significant only at 30 mg/kg. Ch levels showed an increase in all the brain regions but a significant increase was only seen in medullapons, midbrain and cortex regions. Although there are a number of similarities among the effects of various cannabinoids on central cholinergic mechanisms significant differences exist which suggest that the behavioral effects of cannabinoids are not related to their effects on this neurotransmitter. (Supported by USPHS grants DA-00326, DA-00490 and DA-07027).

FOREBRAIN NEURAL ACTIVITY AND ELECTRICAL STIMULATION OF THE MIDBRAIN NAFHE. K.W. Waller and J.H. Johnson. Dept. of Anatomy, Med. Col. of Va., Richmond, VA 23298

The present preliminary studies show effects of electrical stimulation of the midbrain on neural activity of forebrain areas known to influence gonadotropin release. Midbrain regions in 8 long-term ovariectomized rats were stimulated with 1 mA 50 μ sec biphasic constant current pulse pairs at 10Hz, 30 sec on/off for one hour through chronically-implanted electrodes. Multiple unit activity (MUA) was recorded from the preoptic area (POA) and dorsal hippocampus (DHPC) one hour before, during, and one hour after stimulation. Blood samples obtained at 10-minute intervals via a jugular catheter were assayed for luteinizing hormone (LH). A decrease in blood LH appeared to accompany a rise in the minima reached by integrated preoptic MUA in both control and stimulation periods ($n=1$). LH levels decreased during stimulation of dorsal raphe. DHPC activity increased during DR stimulation and remained elevated 30-40 minutes beyond the stimulus. Stimulation of lateral periaqueductal gray regions ($n=3$) was followed by increases in DHPC or POA activity for the duration of the recording, suggesting a more generalized neural activation. These preliminary data tentatively suggest inverse relationships between preoptic or hippocampal MUA and LH release in the ovariectomized rat.

COMPARISON OF THE ANTINEOPLASTIC ACTIVITY AND TOXICITIES OF THE SODIUM AND CALCIUM SALTS OF MALEIC VINYL ETHER COPOLYMER (MVE). K.L. White, Jr.*, P.C. Klykken*, and A.E. Munson.

Dept. of Pharmacology, Med.Col. of VA/VCU, Richmond, VA 23298

Maleic Vinyl Ether copolymer (MVE) has been shown to have both antineoplastic and antiviral activities. These activities are related to the molecular weight (MW) of the copolymer fraction with MVE-4 MW 32,000 being more efficacious than MVE-2 MW 15,500. Acute toxicity, characterized by immediate onset of convulsions, respiratory depression and cardiovascular collapse, results in death within 3 min. of intravenous injection. The Na salt and Ca salt (30% neutralized) of MVE-2 and MVE-4 were compared in Balb/c mice for acute toxicity, sensitization to lipopolysaccharide (LPS), and antineoplastic activity. I.V. administration of the Ca salt of MVE-2 produced a LD₅₀ of 213 mg/kg while the Na salt resulted in a LD₅₀ of 60 mg/kg. Similarly, the Ca salt of MVE-4 had a LD₅₀ of 199 mg/kg compared to LD₅₀ of 45 mg/kg for the Na salt. While the Na and Ca salts of MVE-2 equally increased susceptibility of mice to the lethal effects of LPS, the Ca salt of MVE-4 decreased sensitivity to endotoxin by 3-fold. In mice bearing Madison 109 lung carcinoma, weekly I.V. administration of 25 mg/kg of the Ca salt of MVE-2 decreased growth rate of the primary tumor by 54%. However the Na salt of MVE-4 was more efficacious than the Ca salt, producing a 72% decrease in primary tumor growth. Mean survival time (MST) followed the same pattern. These studies indicate that the Ca salt of MVE-2 markedly decreases the acute toxicity while significantly increasing the antineoplastic activity.

5p-SYNDROME: A SURVEY OF 62 NON-INSTITUTIONALIZED PATIENTS. L.E. Wilkins†, J.A. Brown, Ph.D.* Dept. of Human Genetics, Med. Col. of Va., Richmond, Va. 23298

The Cri du Chat syndrome (5p-) is a rare chromosome abnormality in man with an incidence of 1 in 50,000 live births. Data from previous studies of institutionalized Cri du Chat individuals have resulted in a clinical picture with a grim prognosis. This study has demonstrated that the Cri du Chat child can be raised at home and with special schooling can attain the skills of a normal 6 to 7 year old child. We present data on 62 non-institutionalized Cri du Chat patients which were obtained from parental questionnaire response and medical records. The subjects ranged from 2 months to 26 years of age and included 1.8 times more females than males.

A wide range of variability was evident in the child's condition at birth, the severity of the physical malformation and the level of mental development. While significant neonatal complications suggestive of Cri du Chat were present in 24% of the subjects, 41% were considered normal at birth. Social quotients ranged from 6 to 85. The variability in the developmental characteristics of these children was examined with respect to the child's condition at birth, the presence of chronic illness and the age at starting school. The impact on both the child and parents of early infant stimulation and preschool programs will be presented in detail. Frequently noted health problems and medical complications encountered when raising the Cri du Chat child at home will be discussed.

INHIBITORS OF RAT LIVER HMG-CoA REDUCTASE AS POTENTIAL HYPO-CHOLESTEROLEMIC AGENTS. Yeong-Maw Yeh¹, M. R. Boots, Dept. of Pharmaceutical Chemistry, Med. Col. of Va., VCU, Richmond, VA 23298, and S. G. Boots², Dept. of Chemistry, Stanford Univ., Stanford, CA

HMG-CoA reductase mediates the rate-limiting step of mammalian cholesterol biosynthesis. Inhibition of this reaction provides the most efficient inhibition of the entire biosynthetic pathway and thereby hopefully causes a reduction of serum cholesterol levels. Our previous work indicated that the presence of a 3-hydroxyl group in arylalkyl hydrogen glutarates increases inhibitory activity. In an attempt to obtain additional information concerning the molecular requirements for inhibition of HMG-CoA reductase a series of 1-(4-biphenyl)-n-pentyl hydrogen 3-hydroxy-3-alkyl and 3-alkyl glutarates were prepared and evaluated. The 3-alkyl series was specifically designed to determine if there was a hydrophobic binding site on the enzyme where the 3-alkyl group of the glutaric acid moiety could bind. The 3-hydroxy-3-alkyl series was investigated to determine if binding to the hydrogen bonding site via the hydroxy group and the hydrophobic site via the 3-alkyl group on the enzyme could occur simultaneously. The synthesis and biological evaluation of these inhibitors will be discussed.

Microbiology

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

INFLUENCE OF CHRONIC AFLATOXICOSIS ON VIRUS INFECTION IN THE MOUSE. G.R. Bryson,* P.H. Hartig,* G.C. Llewellyn and S.R. Webb. Biology Department, Virginia Commonwealth Univ., Richmond, Virginia 23284

Encephalopathy and visceral fatty degeneration (EVFD) diseases occur with rapid onset and cause high mortality in affected youths. Though their etiology has not been established, increased incidence of these diseases has followed viral epidemics in societies subject to high environmental toxin levels. C57BL/6 male mice, 5 weeks old, were segregated into two groups: one group was fed Lab Chow, the other was fed Chow supplemented with 10.7 ppm mixed aflatoxin throughout the experiment. After six weeks, half of the mice in each group was infected by i.p. injection with 300 PFU of Coxsackievirus B₄ (CUB₄) and examined at 4 and 21 days after infection. At the time of infection toxin and chow animals were the same weight and had the same levels of plasma SGOT, BUN, insulin, and blood glucose. However, toxin caused vacuolization of hepatocytes and mitochondrial swelling. Virus replicated to the same high titers in liver, pancreas and kidney of both groups. SGOT and BUN were similarly elevated during the acute stage and surviving mice were relatively normal by 21 days post infection. C57BL/6 mice were extremely resistant to aflatoxins and thus viral potentiation was negligible in this virus-host system.

CHARACTERIZATION OF NORMAL AND TUMOR-BEARING MOUSE SOLUBLE MACROPHAGE REGULATORS OF T CELL BLASTOGENESIS. K. M. Connolly,* K. D. Elgert, and J. M. Conroy,* Dept. of Biology, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061

Macrophage (M_φ) regulation of mixed lymphocyte reaction (MLR) reactivity in murine T lymphocytes appears to be a non-contact, concentration dependent phenomenon. That is supernatants from high concentrations of peritoneal M_φ inhibited while low doses enhanced MLR activity. Supernatants contained a heat stable inhibitor factor; nonthymidine in nature as shown by dialysis and competitive inhibition experiments. Treatment of M_φ with indomethacin did not abrogate release of inhibitor factor, thus indicating its non-prostaglandin composition. Heat labile enhancing factor, obtained from M_φ sonicates as well as supernatants, could be distinguished from lymphocyte activating factor by its inability to induce a thymocyte phytohemagglutinin response. In initial biochemical experiments inhibitor and enhancing factors could be separated by charge, using anion exchange chromatography. When regulatory activity of normal supernatant was compared to that of tumor-bearing mice (TBM) M_φ supernatants, results indicated that TBM M_φ supernatants contained a greater ability to induce MLR reactivity than their normal counterparts. Thus, it appears that the splenic T cell hyporeactivity seen in fibrosarcoma-bearing mice cannot be totally attributed to the presence of a inhibitory TBM M_φ.

ENZYME-LINKED IMMUNOSORBENT ASSAY FOR CYTOMEGALOVIRUS DETECTION. R.S. Fowler, M.R. Escobar, N.J. Reedy and C.W. Moncure. Med. Coll. of Va.-Va. Comm. Univ., Richmond, Va.

The low recovery of human cytomegalovirus (CMV) from clinical specimens as well as the time-consuming, costly and tedious procedure for its isolation and identification led us to search for a better method. An enzyme-linked immunosorbent assay (ELISA) consisting of a double antibody sandwich technique using horseradish peroxidase as an enzyme maker was developed for the detection of CMV antigen. The optimum incubation times and temperatures for the various steps in the assay which produced the maximum sensitivity for the detection of antigen were determined. The optimum concentration of solid phase antibody and of conjugate were also defined. A confirmatory test using blocking antibody was performed to ascertain the specificity of the assay. CMV antigen from two sources was tested. Other members of the herpesvirus group were used as controls to demonstrate the specificity of this procedure.

PRELIMINARY OBSERVATIONS ON METHODOLOGIES FOR ISOLATING AND ENUMERATING PATHOGENIC BACTERIA FROM SHELLFISH GROWING WATERS. Mark T. Frank* and Carl W. Erkenbrecher. Old Dominion University, Norfolk, Virginia, 23508

The methodologies for improved recovery of pathogenic bacteria from estuarine sediments were investigated. Samples were collected from five sites horizontally distributed throughout the Lynnhaven estuary in Virginia Beach, Virginia. A review of current and past data of these shellfish growing waters has shown high fecal coliform counts in the water column and in the sediments. Our preliminary studies in these same sediments have centered around the enumeration of three pathogenic bacteria: *Salmonella* spp., *Pseudomonas aeruginosa* and *Vibrio parahaemolyticus*. Enrichment procedures in addition to elevated temperature techniques have been employed. Asparagine broth and dulcitol selenite broth were utilized to isolate *Salmonella* spp. and *P. aeruginosa*, while seawater yeast extract broth was used for *V. parahaemolyticus*. Genera and species have been determined by plating of these enrichment cultures on selective and differential media, followed by biochemical testing procedures. *P. aeruginosa* and *V. parahaemolyticus*-like-organisms (VPL0) have been isolated with some degree of consistency, while the *Salmonella* spp. have remained elusive. Preliminary results have re-emphasized the difficulties experienced by previous investigators in search of increased sensitivity techniques for detecting specific pathogens in sediments already demonstrated to be high in fecal indicator bacteria.

COMPARISON OF ANTIGENICITY OF CULTURED AND FRESHLY ISOLATED ANABAENA AZOLLAE. THE NITROGEN FIXING PHYCOBIONT OF THE AZOLLA FERN. T. Goppin*, J. Gates, P. Wood*, and R. Fisher* Dept. of Biology, Virginia Commonwealth University, Richmond, VA 23298

Antisera were prepared against freshly isolated *Anabaena azollae* cells from *Azolla caroliniana* and against Newton's culture of *A. azollae*, also from *Azolla caroliniana*. These antisera were used in a cross reaction study using indirect fluorescent antibody staining. The serum prepared against freshly isolated cells gave a strong reaction with cells of *A. azollae* freshly isolated from either *Azolla caroliniana* or *Azolla microphylla*. It did not react with Newton's culture of *A. azollae*, our culture of *A. azollae*, or with the free-living cyanobacteria, *Anabaena cylindrica* or *Cylindrospermum licheniforme*.

The serum prepared against Newton's culture reacted with cells from Newton's culture, our culture, and with the above named free-living species; however, it did not react with freshly isolated cells of *A. azollae* from either fern species.

These results indicate that either antigenic changes occur in *A. azollae* during culturing or that the organism cultured independently by Newton and us is not really *A. azollae*. They also provide evidence that the two species of *Azolla* have the same phycobiont, a hypothesis which heretofore has been unsubstantiated.

PURIFICATION AND CHARACTERIZATION OF AN NADH:FLAVIN OXIDOREDUCTASE FROM *EUBACTERIUM* SPECIES (V.P.I. 12708). R. H. Lipsky and P. B. Hylemon. Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23298

A NADH:Flavin oxidoreductase was purified from a *Eubacterium* sp. (V.P.I. 12708) using Bio-Gel A-0.5, DEAE-cellulose and affinity column chromatography. The last purification step was performed on 6-aminohexanoyl-FMN-Sepharose. Specific activity was calculated from the decrease in absorbance at 340 nm. Assays were performed anaerobically to minimize autooxidation of the reduced flavin. A molecular weight (M_r) of 260,000 was estimated by gel filtration chromatography. The partially purified enzyme preparation was found to exhibit single displacement kinetics with respect to the substrates NADH and FAD. Maximal specific activity was achieved when these substrates were in a molar ratio of 1:1. The pH optimum under these conditions was 6.8. A NADPH:Flavin oxidoreductase was also detected in crude cell extracts of *Eubacterium* sp. (V.P.I. 12708). However, this enzyme activity could be differentiated from the NADH-dependent flavin oxidoreductase on the basis of molecular weight (M_r of NADPH-dependent enzyme was approx. 250,000) and the differential change in the specific activity with respect to culture age.

MACROLIDE-LINCOSAMIDE-STREPTOGRAMIN-R-PLASMID DERIVATIVES. F.L. Macrina, K.R. Jones* and C.L. Keeler*. Department of Microbiology, Virginia Commonwealth University, Richmond, VA 23298.

Our goal is to develop a molecular cloning vehicle for use in a *Streptococcus sanguis* "self-cloning" system. pAM1 is a 17 Md plasmid which occurs naturally in *S. faecalis* and confers resistance to macrolide-lincosamide-streptogramin (MLS) antibiotics. This plasmid has been introduced into *S. sanguis* by genetic transformation. Following transformation into *S. sanguis*, we have found a deletion-bearing derivative of pAM1 which we have designated pZAI. This plasmid is 7.3 Md in size and contains 4 Hind III restriction endonuclease cleavage sites, 2 EcoRI cleavage sites, and 1 Hpa I cleavage site. Single and double digests of this molecule with these three enzymes has allowed us to establish a restriction map of the pZAI plasmid. Partial digestion of pZAI with Hind III was followed by ligation with DNA ligase and these pZAI fragments were used to transform *S. sanguis* to erythromycin resistance. To date, no in vitro-shortened derivatives of pZAI have been obtained by this method. (Supported by NIH-NIDR Grant DE04224.)

CHARACTERISTICS OF MACROPHAGES FROM THE BEIGE MOUSE. K.H. Mahoney*, S.S. Morse* & P.S. Morahan. Dept. of Microbiol., Va. Commonwealth Univ., Richmond, Va. 23298.

The Chediak-Higashi Syndrome (CH) is a genetic disease characterized by abnormal lysosomes in several cell types including neutrophils and macrophages (M ϕ). Recent evidence implicates lysosomes in M ϕ antitumor activity. We have defined several aspects of the antitumor activity of *C. parvum* activated M ϕ from the beige (C57BL/6J bg/bg) mouse, a CH homologous, and congenic C57BL/6 +/+ controls.

Yields of resident peritoneal cells (PEC) were similar in bg and controls (3x10⁶/mouse), with about 30% M ϕ (by acridine orange). After treatment of mice with killed *C. parvum* (70 mg/kg, i.p., day -7), M ϕ increased to about 50% in both bg and controls. *C. parvum* treatment also produced similar splenomegaly in the two groups. In an in vitro 72 hr morphologic antitumor assay, bg M ϕ were as cytotoxic for the Lewis lung carcinoma target cells as were control M ϕ . Kinetics of cytotoxicity were determined in an in vitro ³H-dTR release assay. The bg M ϕ (10:1 M ϕ :target cell ratio) showed a delay in cytotoxicity, at 12 hr exhibiting only 30% as much activity as controls. In spite of the delay, by 24 hrs the bg M ϕ had 80% of the control activity. Our results suggest that bg M ϕ may be deficient in some aspects of tumor cytotoxicity. This defect may be related to the delayed bactericidal activity of CH phagocytes. (Supported by CA 06332, AI 70863, CA 24606, and ACS 1N-105c.)

TRANSFER OF MULTIPLE ANTIBIOTIC RESISTANCE IN CLINICAL ISOLATES OF BACTEROIDES. T.D. Mays, R.A. Welch* and F.L. Macrina. Department of Microbiology, Medical College of Virginia, Virginia Commonwealth Univ., Richmond, VA 23298. The in vitro transfer of clindamycin and tetracycline resistance was observed from a clinical isolate of *Bacteroides fragilis* (V503) to a fecal isolate of *Bacteroides uniformis* (V528). The transfer of this multiple drug resistance was accompanied by two plasmid species: 3.7 and 7.5 megadaltons (Md) in size.

Bacteroides fragilis (V503) donor cells (rifampicin sensitive) were mated with spontaneous rifampicin resistant mutants of V528 on nitrocellulose membrane filters and incubated on agar plates anaerobically. Transfer frequencies of 1.8×10^{-6} to 2.2×10^{-7} transipients per donor cell were observed using donor cells at different phases of growth. In this system, donor cells in the early logarithmic phase of growth appeared to transfer at a frequency 10-fold greater than cells at later stages of growth. Experiments are in progress to determine whether this increased frequency of transfer is due to the growth phase of the donor cells or an increased period of mating.

This transfer mechanism was insensitive to deoxyribonuclease I and required cell to cell contact. Transfer was not observed when either chloroform treated or 0.45 μ m filtrates of donor cultures were used.

IMMUNE RETENTION: IMMUNOLOGICAL REQUIREMENTS FOR MAINTAINING AN EASILY DEGRADABLE ANTIGEN IN VIVO. G.A. MILLER, J.G. Tew, and T.E. Mandel*, Dept. of Microbiology, Medical College of Virginia, Richmond, Virginia 23298.

Radioactive human serum albumin (¹²⁵I-HSA) was injected into the hind foot pads of unimmunized mice, actively immunized mice, and mice passively immunized with anti-HSA. Eleven days later, the unimmunized mice had cleared the ¹²⁵I-HSA but in immunized mice, most was retained in the feet and draining lymph nodes, and to a lesser extent, in the spleen. Immune retention required specific antibody, but was independent of T-cells since passively immunized nude mice retained antigen as well as actively or passively immunized normal mice. Cobra venom factor (CVF) treatment increased antigen retention in the feet but decreased retention in the spleen. CVF did not decrease antigen retention in lymph nodes of actively immunized mice but did decrease retention in lymph nodes of passively immunized mice, although not to the same extent as in the spleen. Retention of antigen in the feet was Fc independent since F(ab')₂ fragments of anti-HSA could mediate retention. Antigen dose response studies indicated that optimal retention in lymph nodes required smaller amounts of antigen than for the feet. Foot pad injections of non-radioactive HSA eliminated 60% of the radioactivity retained in the foot pads of immunized mice but egg albumin (EA) had almost no effect. However, if the mice were immunized to both EA and HSA, an injection of EA would displace the HSA. Supported by NIH Grant No. AI-11101.

ENUMERATION OF ENTERIC AND OTHER VIRUSES IN WASTEWATER

SLUDGES: A PRELIMINARY REPORT. M.W. Nath* and J.C. Johnson, Dept. of Biosciences, Old Dominion Univ., Norfolk, Va. 23508.

With wastewater sludge reutilization becoming more important and disposal increasingly regulated, it has become necessary to determine amounts of specific and hazardous pollutants in sludges. Viruses are a class of biologically hazardous pollutant found in varying amounts in sludge and upon occasion have been demonstrated the etiologic agents responsible for human disease. Improvements in detection and enumeration of viruses in wastewaters are being sought. We have studied the ability of common surfactants [sodium dodecyl sulfate (SDS), tweens 20 (T-20) and 80 (T-80), Nonidet P40 (NP-40), Tritons X-100 (X-100) and X-200 (X-200)], fetal bovine serum (FBS), beef embryo extract (BEE), and NaCl to extract poliovirus-2 (Pc-2), coxsackievirus B2 (Cox-B2), and Anatis herpesvirus (AHV) from seeded wastewater sludge. Surfactant concentrations found to be non-cytotoxic were equal to or less than 0.05% v/v. Pc-2 was most efficiently placed on RD (CCL-136) followed by buffalo green monkey (BGM), VERO (CCL-81), and WI-38 (CCL-75); Cox-B2 on BGM followed by WI-38, VERO, and LLC-MK₂ (CCL-7.1); and AHV on duck embryo fibroblasts (DEF) exclusively. The efficiency of extraction of enteric viruses was least using T-20 or T-80 (≈15%) and greatest using either SDS or NaCl (≈75%) in single extraction at 4°C and greater than 95% using SDS and NaCl in single or double extraction at 15°C.

TRANSCRIPTION OF THE NONDEFECTIVE BOVINE PARVOVIRUS. J. T. Patton, E. R. Stout, and R. C. Bates, Dept. of Biology, Va. Poly. Inst. and State Univ., Blacksburg, Va. 24061.

Viral-specific RNA (vRNA) produced in bovine parvovirus (BPV)-infected bovine fetal spleen cells continuously labeled with ³H-uridine was examined by hybridization, poly(U)-Sephacrose chromatography, and gradient centrifugation. The levels of BPV-specific RNA late in infection were examined by exhaustive hybridization in 50% formamide. vRNA represented 3.1, 3.2, and 6.8% of the RNA found in the total cell, nuclei, and polysomes, respectively. Separation of the nuclear and polysomal RNA by poly(U)-Sephacrose chromatography into poly(A)⁺ and poly(A)⁻ fractions, followed by hybridization, showed that 18.2 and 25.4% of nuclear and polysomal poly(A)⁺ RNA respectively was vRNA while 3.1 and 6.1% the nuclear and polysomal poly(A)⁻ RNA was vRNA. These results suggest substantial levels of polyadenylation of the BPV vRNA.

The template specificity of vRNA was determined by competitive hybridization of ³H-vRNA and BPV vDNA for immobilized BPV vDNA-cDNA. Competition of vRNA and 10 µg of vDNA resulted in 2.4% vRNA binding to the immobilized DNA suggesting that the template for polysomal poly(A)⁺ vRNA (viral mRNA) is BPV vDNA. Polysomal poly(A)⁺ RNA was sized by centrifugation through 0-15% sucrose containing 99% dimethyl sulfoxide. Subsequent hybridization of fractions from the gradient indicated a major peak of vRNA at 25-26 S which corresponds to a transcript length which is 70-80% of the BPV genome.

ISOLATION OF TEMPERATURE-SENSITIVE ALGINIC ACID BIOSYNTHETIC MUTANTS OF *MUCOID PSEUDOMONAS AERUGINOSA*. R. Robins*, D.O. Wood*, J.S. Karns*, F.L. Macrina and P.V. Pribbbs, Jr. Dept. of Microbiology, Virginia Commonwealth Univ., Richmond, VA.

Alginate acid-producing mucoid strains of *Pseudomonas aeruginosa* frequently cause chronic respiratory infections in cystic fibrosis patients. We report the isolation of mutants affected in the biosynthesis of this exopolysaccharide. A mucoid, clinical isolate (V388) produces an increasing amount of extracellular alginate as the temperature rises with peak production (45 µg per 10⁹ cells at 32°C, 68 µg per 10⁹ cells at 37°C, and 90 µg per 10⁹ cells at 42°C) occurring at the end of log phase growth in basal salts glucose medium. A spontaneously occurring, non-mucoid variant (V389) grown under similar conditions produces no detectable alginate when assayed for uronic acids using a colorimetric borate-carbazole method. Mid-log phase cells of V389 were exposed to ethyl methanesulfonate. Survivors were plated on a complex medium and incubated at 42°C. Non-mucoid colonies appearing after 24 hr were selected and observed for the mucoid phenotype when grown at 32°C for 24 hr. One mutant (V578) isolated in this manner exhibits a growth rate indistinguishable from that of V388, but produces alginate at greatly reduced levels, especially at 42°C (17 µg per 10⁹ cells at 32°C, 31 µg per 10⁹ cells at 37°C, and 12 µg per 10⁹ cells at 42°C). This work was supported by a grant from the National Cystic Fibrosis Foundation.

PAPER RADIOIMMUNOSORBENT ASSAY FOR THE DETECTION OF HEPATITIS B VIRUS ANTIGENS AND ANTIBODIES. N.J. Reedy, P.D. Swenson, H.M. Syrop, and M.R. Escobar. Med. Coll. of Va.- Va. Comm. Univ., Richmond, Va.

The collection of blood, its handling and processing for the detection of various markers of Hepatitis B virus infection is impractical and hazardous, especially for field testing. In this study, a simple procedure was evaluated, consisting of spotting a drop of whole blood from a finger puncture on a 2x2 cm square of Whatman #4 filter paper. The paper was dried, placed in a polypropylene tube and refrigerated until tested. Prior to testing, it was immersed for 30 minutes in 3 ml of 0.85% NaCl. The resulting suspension and serum from the same patient were then tested by AUSAB-II, AUSAB, and CORAB techniques. HBsAg positive results done in triplicate from the paper method correlated 100% for sensitivity and specificity with those using serum. In contrast, the paper method only detected 67% and 25% of the serum specimens found to be positive by AUSAB and CORAB, respectively. Further work is underway to increase the sensitivity by the latter two methods.

LONG-TERM ANTIGEN RETENTION ON MOUSE TENDONS: A MECHANISM FOR INDUCTION OF LOCAL HYPERSENSITIVITY STATES. Patricia L. Rice, John G. Tew, and Terrell A. Thompson, Department of Microbiology, Med. Coll. of Va., Richmond, Va. 23298.

It has been reported by our laboratory that human serum albumin (HSA), an antigen (Ag) easily degraded *in vivo*, is retained intact for long periods of time (T_{1/2} = 2mo) in the feet, lymph nodes, and spleen of HSA-immune mice. The same situation is not seen in non-immune mice, instead the Ag is rapidly cleared from these sites. The objective of this study was to establish where in the foot Ag was retained, and to determine if a hypersensitive state could be locally and specifically induced at the site of Ag retention in the foot. 125I-HSA was injected into the hind feet of HSA-immune and non-immune mice. Autoradiography of the feet revealed that the majority of the 125I-HSA was found in association with the flexor tendon. Injecting small amounts of HSA into feet retaining HSA elicited foot pad swelling. Also, it was found that in mice immunized months earlier foot pad swelling could be induced by administering specific Ag by gavage or injecting it intraperitoneally. In contrast, the feet of mice primed by routes other than the foot pad, or foot pad immunized mice challenged with non-specific Ag, did not swell. The data suggest a possible mechanism for the induction of hypersensitivity states since it appears that minute amounts of Ag in the circulation can act in conjunction with Ag retained on the flexor tendon to elicit an inflammatory response at the local site. (USPHS NIH Grant AI-11101)

THE EFFECT OF GLUCOSE STARVATION ON THE GLUCOSE TRANSPORT SYSTEM OF THE YEAST *KLUYVEROMYCES LACTIS*. Paulette M. Royt, Biology Department, George Mason University, Fairfax, Va. 22030.

The inducible glucose transport system of the yeast *Kluyveromyces lactis* is rapidly inactivated upon glucose starvation. This inactivation does not require energy. An inhibitor of RNA synthesis, 8-hydroxyquinoline, has no effect on the loss of activity. In the absence of both glucose and nitrogen inactivation does not occur, whereas nitrogen starvation in the presence of glucose results in a moderate decrease of carrier activity. Glucose-starved, wild type cells require glucose, nitrogen, and RNA synthesis to regain transport activity. A uracil-requiring mutant of this yeast requires uracil as well as glucose to regain carrier capacity. These results suggest that the glucose carrier of this yeast is subject to proteolytic modification by an existing protease, for to restore transport activity following glucose starvation synthesis of new carrier molecules must occur. (Aided by GMU Research Grant 2-10013)

NEW SOLID-PHASE IMMUNOFLOURESCENCE METHOD FOR SYPHILIS. R. J. Talliaferro, M.R. Escobar, J.N. Reedy and C.W. Moncure. Med. Col. of Va. - Va. Comm. Univ., Richmond, Va.

The Fluorescent Treponemal Antibody-Absorption (FTA-ABS) test is the conventional qualitative procedure for detection of antibodies to *Treponema pallidum*. Although it is highly sensitive, it is subjective, time-consuming, and tedious for routine testing. This study was concerned with the adaptation of the FTA-ABS to a recently developed fluoroimmuno-metric assay system (FIAx) using a cellulose acetate reacting surface. Several parameters were tested, including optimal buffer, pH, conjugate dilution, antigen concentration as well as the effect of various agents on specificity and reactivity. A total of 195 sera and 45 cerebrospinal fluid (CSF) specimens were tested under standard conditions. Of 150 FTA-ABS reactive sera, 147 (98%) were also reactive by FIAx. Of 45 FTA-ABS nonreactive sera, only 34 (76%) were nonreactive by FIAx. Of 43 FTA-ABS nonreactive CSF, 42 (98%) were also nonreactive by FIAx. Of the other 2 FTA-ABS reactive CSF, only 1 was reactive by FIAx. Of 35 FTA (unabsorbed) nonreactive CSF, 100% were nonreactive by FIAx. Of the 10 FTA reactive CSF, only 2 (20%) were reactive by FIAx. Further investigation on the basis of a close clinico-laboratory correlation is warranted to determine the comparative specificity of the two methods. Advantages of the FIAx include objectivity, automation, potential for quantitation and simplicity which justify its further evaluation.

COMPARISON OF HETEROCYSTS IN FREE-LIVING CYANOBACTERIA AND THE PHYCOBLIOT OF THE AZOLLA FERN. P. Tomlinson*, R. Fisher* and J. Gates. Department of Biology, Virginia Commonwealth University, Richmond, Virginia 23284.

In nature, the water fern *Azolla* normally forms a symbiotic association with the cyanobacterium *Anabaena azollae*. This association can fix diatomic nitrogen and can therefore be important agriculturally. The site of this nitrogen fixation is in special cells of the cyanobacterium, called heterocysts. In our studies with *A. azollae* we have sought a rapid and accurate method to identify heterocysts.

In the course of our studies with the *Azolla* complex, we have noticed a difference in the fluorescence spectra of vegetative cells and heterocysts. The heterocysts of all free-living cyanobacteria examined failed to fluoresce when excited with 530 nm light. The vegetative cells did fluoresce. This difference makes it possible to identify heterocysts.

However, heterocysts of *A. azollae* did fluoresce, thus making the fluorescent method ineffective. Other methods, utilizing nuclear emulsion, nitro blue tetrazolium (NBT) and triphenyl tetrazolium chloride (TTC), were examined for use with *A. azollae* heterocysts. NBT was shown to be the best.

The nature of the difference in the fluorescence of the heterocysts of free-living cyanobacteria and those of *A. azollae* is now under study.

CHARACTERIZATION OF BACTERIOIDES R PLASMID DELETION MUTANTS. R.A. Welch* and F.L. Macrina. Dept. of Microbiology, Med. College of Virginia, Virginia Commonwealth Univ., Richmond, VA 23298.

Bacteroides fragilis strain V514 possesses a transferable R plasmid, pBF5 (60 Mdal), which confers resistance to clindamycin, erythromycin and tetracycline. A spontaneously occurring tetracycline sensitive variant of V514 has been isolated (V479-1) which possesses a 27.3 Mdal plasmid, pBF4, conferring transferable clindamycin and erythromycin resistance. Following growth in the presence of ethidium bromide, clindamycin-erythromycin sensitive variants of V479-1 and V514 have been isolated. Reversion by these strains to clindamycin resistance is undetectable ($<10^{-9}$) even when cells are grown in the presence of various mutagens. Plasmid size analysis of clindamycin sensitive derivatives of V479-1 and V514 indicate that the pBF4 and pBF5 plasmids have undergone a deletion amounting to 5 Mdal of DNA. When the deletion-bearing plasmid derivatives are digested with restriction endonucleases, the deletions can be associated with the loss of specific digest fragments, thus enabling us to localize the clindamycin resistance determinant. (Supported by NSF Grant PCM 77-00858.)

WATER-TO-AIR TRANSFER OF POTENTIAL MYCOBACTERIAL PATHOGENS IN RICHMOND. S.L. Wendt*, B.C. Parker, and J.O. Falkinham, III. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Our data show that potentially pathogenic atypical mycobacteria of the *Mycobacterium avium*-*M. intracellulare*-*M. scrofulaceum* (MAIS) group occur in James River fresh-water, their aerosols, and rainwater from Richmond, Virginia. The recovery of 21 strains of MAIS-group mycobacteria, biochemically similar to those isolated from man, confirms the existence of a natural mechanism for the transfer of significant numbers of atypical mycobacteria from their freshwater reservoirs into the air. Four aerosol isolates were associated with droplets of a size capable of penetrating the human alveoli and 10 others could be infective if their associated droplets decreased in size via evaporation. Atypical mycobacteria are more abundant in freshwaters than marine waters of the southeastern United States and are less commonly recovered from samples from the northeastern states. These findings support our hypothesis that aerosolization of atypical mycobacteria from waters of the southeastern United States may be important for human infection.

RADIOLABELING IN NAEGLERIA. T.W. Woodworth*, S.G. Bradley, H.L. Pringle and W.M. Holmes. Dept. Microbiology, Va. Commonwealth Univ., Richmond, VA 23298.

Naegleria fowleri and *N. gruberi* are amoeboid flagellates that feed and grow as amoeboid cells but can transform into flagellated cells within 1 hr after nutrient deprivation. *N. fowleri* is the agent of primary amoebic meningoencephalitis in man; *N. gruberi* is non-pathogenic. Both species normally inhabit fresh water environments. *N. fowleri* may be cultivated axenically in Nelson's medium (0.1% Tiver digest, 0.1% glucose and 2% calf serum in inorganic salts), growing with a generation time of 12.7 hr to a yield of 1.2×10^6 amoebae/ml. *N. gruberi* has been grown axenically in Balamuth's medium (0.5% yeast extract, 0.5% glucose, 1% liver digest, 1% proteose peptone in inorganic salts) with a 7.4 hr generation time to a yield of 3×10^6 amoebae/ml. For radiolabeling, Balamuth's medium is too complex. One strain of *N. gruberi*, NEG-M, has been cultivated in M7 medium (0.5% yeast extract, 0.03 mM glucose, 0.3 mM methionine, 8% dialyzed calf serum and phosphate buffer). *N. fowleri* incorporates adenine, uridine, thymidine, leucine and serine but not sulfate during growth in Nelson's medium. *N. gruberi* NEG-M, during growth in M7 medium, incorporates methionine, but not glutamate, aspartate, leucine, serine or sulfate, into trichloroacetic acid precipitable protein. Optimization of axenic growth and radiolabeling is a necessary prelude to future studies of macromolecular events accompanying the amoeba-flagellate transformation. Work supported by ACS Grant (IH-105 D.)

FOCAL HEPATIC NECROSIS IN VARIOUS STRAINS OF MICE AS A MARKER FOR HERPESVIRUS HOMINIS TYPE DIFFERENTIATION. J.M. Tamm, M.R. Escobar, N.J. Reedy and H.M. Syrop. Med.Col. of Va. - Va. Comm. Univ., Richmond, Va.

The production of focal, macroscopic, hepatic necrosis in mice as a marker for differentiating herpesvirus hominis type 1 (HVH-1) from type 2 (HVH-2) was investigated. AKR-J, BALB/cByJ, C57BL/6J and ICR mice were evaluated and compared as models. The AKR/J and ICR strains produced hepatic lesions following intraperitoneal inoculation of both HVH-1 and HVH-2. The C57BL/6J mice exhibited no lesion production following injection with either virus type. In contrast, BALB/cByJ animals showed 100% specificity and 70% sensitivity of lesion production following injection with HVH-2, respectively. The relatively low degree of sensitivity appears to be the limiting factor in the focal hepatic necrosis test. This method was compared to the plaque assay in chicken embryo fibroblast monolayers, indirect hemagglutination inhibition, direct immunofluorescence and pock production on the chorioallantoic membrane of embryonated chicken eggs, thus showing good correlation with all, except the latter procedure. For this reason, focal, hepatic necrosis was proposed as a confirmatory test or as a member of a battery for HVH type differentiation.

ELECTRON MICROSCOPIC VISUALIZATION OF BOVINE PARVOVIRUS DNA.
R. B. Young and R. C. Bates, Dept. of Biology, Va. Poly.
Inst. and State Univ., Blacksburg, Va. 24061.

The parvoviruses contain a linear single-stranded DNA genome with palindromic sequences at the 3' and 5' termini. The proposed Berns and Hauswirth model for replication of these viruses calls for the conversion of the single-stranded DNA to a duplex replicative form using the 3' palindrome or hairpin as a primer for DNA synthesis. Progeny DNA strands are produced by a single strand displacement mechanism resulting in partially duplex replicative intermediates with single-stranded side chains. Dimer and trimer length replicative forms are also postulated. We report the extraction and purification of several low molecular weight DNA species from bovine parvovirus-infected cells that could not be demonstrated in mock-infected cells. Characterization of these viral DNA species by electron microscopy demonstrated linear duplex molecules with a mean length of 1.69 μ m. These are postulated to be replicative form DNA. Duplex molecules significantly longer than the replicative form DNA with lengths of 2.99 μ m. and 3.99 μ m. were also observed. The lengths of these molecules approach calculated values for dimer and trimer replicative forms. No branched molecules were observed.

Psychology

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

A RE-EXAMINATION OF THE ROLE OF THE LATERAL HYPOTHALAMUS AND AMYGDALA IN PREDATORY AGGRESSION USING KAINIC ACID LESIONS. R. W. BATES*. Sponsor: L. E. Jarrard. Dept. of Psychology, Washington & Lee Univ., Lexington, VA 24450

The lateral hypothalamus and amygdala are part of a predatory aggression circuit. Stimulation of either of these structures elicits (or facilitates) mureicide in rats. Conventional bilateral ablation of either of these structures causes loss of mureicide in mice killing rats.

Kainic acid lesions were used in the present research since these cause no damage to passing fibers as is the case with conventional lesions. The question explored was whether the predatory aggression circuit would stay intact if only the cell bodies and not passing fibers of the amygdala and lateral hypothalamus were destroyed.

Results from lateral hypothalamic lesions were inconclusive. Extensive bilateral damage was obtained in the amygdala of two rats and a third rat had limited bilateral damage. The mureicide tendency of these animals was as strong as in the controls. This suggests that passing fibers play an important role in predatory aggression in rats.

THE EFFECTS OF 36 HOURS OF SLEEP-LOSS ON INFORMATION PROCESSING USING A DIGIT CANCELLATION TASK. R. A. Progan*, R. H. Kirby, and B. B. Morgan, Jr. Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23508

Two groups of subjects, each consisting of 6 males and 6 females, were tested in a study of the effects of 36 hours of sleep-loss (SL) on a digit cancellation task. SL subjects were tested nine times during various stages of sleep loss and 24 hours after the end of the SL period. The control subjects were tested daily for an equal number of times but did not undergo sleep loss. Results showed that sleep loss significantly impaired the improvement of the SL subjects, as compared to the controls. Following 24 hours of rest at the end of sleep loss, the performance of the SL subjects was not different from that of the control subjects.

BEHAVIORAL APPROACHES TO PROMOTING ENERGY CONSERVATION IN A TOWNHOUSE COMMUNITY SETTING. S. E. Churchill*, J. J. Carliyle*, A. W. Fisher*, and J. F. Ferguson*. Sponsor: E. S. Geller. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

An interdisciplinary team of faculty and students at VPI & SU initiated a grant-supported project in the Fall of 1978, entitled Community Action Model for Energy Conservation (CAMEC). The group demonstrated that while energy workshops did promote energy-conservation attitudes, little or no short-term behavioral changes occurred as a result of the workshops. Subsequently, CAMEC initiated a project in a townhouse community to both test the effectiveness of neighborhood workshops and to develop and test new strategies for promoting energy conservation. These strategies included: neighborhood "tupperware-like" workshops, distribution of information packets, energy "hotline" and energy consultant telephone numbers, computer audits of energy usage, and energy usage feedback. Results indicated that these strategies had minimal influence on conservation action, even when the conservation strategy was as convenient as dialing a phone number or completing a simple computer form.

PRELIMINARY EXAMINATION OF ATTITUDES OF THE INDIGENTS OF ROANOKE'S "BLOCK". J. M. Collins*, and A. V. E. Harris. Dept. of Psychology, Radford Coll., Radford, Va. 24142

The current study was an attempt to ascertain self-perceptions of indigents on Roanoke's "block"--an area bordering the city market. Based on previous work by the same author approximately 50 residents of the "block" were personally interviewed regarding their behavior. Most reported a dislike for the conditions under which they lived although most reported pleasure with the cheapness of living, and the presence of others in the same position as they were. While many answers to questions were ambiguous it appeared that alcoholic overindulgence on the part of other residents and the potential for assault were factors most disliked about the area.

So, while many report satisfaction with the block overwhelming evidence points to the fact that the commonly held belief that the block is a tightly knit, well integrated, organized community is a complete myth.

THE COMPUTER AS A GRADE BOOK. James V. Couch, Dept. of Psychology, James Madison Univ., Harrisonburg, Va. 22807.

A general purpose computer program is described which provides individualized student printouts and three different distributions of the student's total scores for the entire class. The advantages of using the computer to perform various data transformations in relation to grading is discussed.

A THERAPIST-CONTROLLED BEHAVIOR MODIFICATION PROCEDURE FOR WEIGHT REDUCTION. L. E. Elliott*, M. Elliott*, and S. E. Lovett, Dept. of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

A therapist-controlled behavior modification procedure for gradual weight reduction was introduced on a reversal design to four obese subjects for 63 weeks. The procedure involved presentation of informative feedback, praise or reproof, and information concerning specific eating behaviors. At the end of the treatment, the subjects had lost an average of 35 pounds. They had regained less than one pound when weighed seven weeks later.

FACTOR ANALYTIC STUDY OF THE ALPERT-HABER ACHIEVEMENT ANXIETY TEST. Terry Garber*, W.E. Turner*, B. English*, C. Grey*, W. Riley*, and J. V. Couch, Dept. of Psychology, James Madison University, Harrisonburg, Va. 22807.

The Achievement Anxiety Test (AAT) was developed by Alpert and Haber in 1960 and purports to indicate not only the presence or absence of test anxiety but also whether the anxiety is of a facilitative or debilitating nature. The test consequently yields two subscores of test anxiety: facilitative and debilitating. The current research sought to determine if the AAT does in fact measure these two kinds of anxiety. The AAT responses of approximately 400 undergraduates were factor analyzed. Correlational data were also obtained between facilitative and debilitating subscores and grade point average. Preliminary results tend to indicate that the AAT is a more effective measure of debilitating anxiety than facilitative anxiety. Several implications and considerations of these results are discussed.

SPATIAL DISTANCE AND SOLIDARITY AS DETERMINANTS OF SOCIAL CONFORMITY. K. L. Hearn*, C. K. Cuddihy*, E. M. Jenkins*, and S. E. Arnold*, Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Our previous research, which manipulated spatial distance between individuals in a social conformity paradigm, demonstrated that social conformity was a direct function of the spatial distance between individuals. The present study manipulated group solidarity in a task immediately preceding a social conformity paradigm in an attempt to influence the extent to which close spatial distance would be perceived as an invasion of personal space.

In summary, the task was a 2(Solidarity: group task versus individual task) x 3(Spatial Distance: inter-subject distance during conformity paradigm—one, four, or eight feet) x 2(Sex of Subject: male versus female) between subjects complete factorial design, with six subjects per condition making a total of 72 subjects.

Questionnaire data verified that manipulations in the initial task affected solidarity in the predicted directions with subjects conforming more following the High Solidarity Condition than following the Low Solidarity Condition. Conformity, however, was not influenced by spatial distance. Additional follow-up research was undertaken to determine moderating factors which determine whether spatial distance influences social conformity.

A COMPARATIVE STUDY OF DIRECTIVE AND NON-DIRECTIVE APPROACHES TO COUNSELING THE MULTIPLY HANDICAPPED. S. H. Patterson, E. Jenkins*, G. A. Hayes*, and E. Scott Celler, Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The comparative effectiveness of two approaches to counseling (directive and non-directive), as employed by undergraduate college students in a therapeutic camp setting, was investigated. The campers were institutionalized, multiply handicapped individuals, classified as severely to profoundly retarded, with a variety of physical disabilities. Prior to camp week, counselors were given 12 hours of general instruction in camper limitations and disabilities, and activity procedures during camp week. Six hours of specific training in both directive and non-directive counseling techniques was provided, via role-playing, group discussion, and direct instruction. Counselors were randomly divided such that half began with the directive approach and switched to the non-directive approach at mid-week and half began with the non-directive approach and switched to the directive. Counselors rated the directive technique significantly more effective on 19 of 20 dimensions tapped, including overall successfulness, effectiveness, efficiency, practicality and involvement. Other dimensions will also be discussed, along with some suggestions for enhancing counselor competency with minimal training.

THE EFFECTS OF KAINIC ACID LESIONS OF THE AMYGDALA ON SPATIAL LEARNING. Andy D. King*. Sponsor: L. E. Jarrard. Dept. of Psychology, Washington & Lee Univ., Lexington, VA 24450.

The involvement of the amygdala in spatial memory was studied in the rat by employing an eight-arm radiating maze. Previous lesioning techniques of the amygdala have destroyed fibers of passage in addition to the cell bodies. In the present study kainic acid was used because it selectively destroys the cell bodies of the structure. Six male albino rats were trained preoperatively to visit all eight arms of the maze without repeating alleys. Bilateral lesions were then made by injecting kainic acid into the amygdala. Following damage to the amygdala cells, the animals performance in postoperative retention did not differ significantly from controls. Thus, these results suggest that the amygdala does not play an important role in retention of spatial information.

PSYCHOMOTOR SPEED AS AN INDEX OF ORGANISMIC INTEGRITY.

H. E. King, Dept. of Psychology, Washington and Lee Univ., Lexington, Va. 24450

The existence of a systematic relation between states of human behavior disorder and faulty psychomotor functioning may be considered, by now, to be an experimentally well-established phenomenon. Psychomotor adequacy has been found to be affected to a measurable degree whenever severe disruptions of adaptive behavior are noted, whether these be of physiologic, psychiatric, or neurologic origin. The empirical evidence supporting this broad statement of contingency will be reviewed, drawing on experimental findings based on populations of psychotic subjects, the brain-damaged and the mentally retarded, from the consequences of human brain-surgical procedures and lower-brain electrical stimulation and from the data of normal subjects performing psychomotor tasks under the influence of drugs, deprivation of essential sleep or oxygen and other manipulated experimental conditions. The parallel found between behavior disorder and the vigor of psychomotor responding offers a practical method for making public and measurable what appears to be a vital aspect of organismic integrity, bringing together for quantitative comparison kinds of behavior disorganization usually thought to be quite independent entities.

SPATIAL LEARNING IN THE RAT AS A FUNCTION OF THE NUMBER OF REWARDED ALTERNATIVE RESPONSES. J. A. Lutins*, W. T. Thistlethwaite*, D. G. Elmes, and J. B. Thompson*. Dept. of Psychology, Washington & Lee Univ., Lexington, VA 24450

The purpose of this study was to examine the memory processes that underlie spatial cognition in the rat. We were interested in the contributions of working memory, the within-trial record of behavior, and reference memory, the long-term record of rewarded loci, on the performance of rats on an eight-armed radial maze. Rats were randomly divided into eight groups, and each subject was required to learn which arm or arms of the eight-armed maze were baited. Group 1 had one baited alley, Group 2 had two baited alleys, and so on through Group 8, which had all eight arms baited. Rats in Groups 1 and 8 performed best as they reached a learning criterion well before the animals in any other group. It was hypothesized that performance in Groups 1 and 8 was best because only one of the two memory systems was required for adequate performance in those groups. On the other hand, animals in the remaining groups (2-7 baited alleys) must utilize differing amounts of both working and reference memory, which results in poorer overall performance. Adequate spatial cognition in the rat requires an efficient use of both reference and working memory.

PROGRESSIVE RELAXATION VERSUS RATIONAL SELF ANALYSIS: TOWARD A SELF-DIRECTED REDUCTION OF ANXIETY. William T. Riley*. James Madison University, Harrisonburg, Va. 22807

Relaxation has been extensively used on college campuses to reduce anxiety. However, little has been done to compare short-term, self-directed relaxation to Rational Self Analysis (RSA). In this study, students randomly selected who received anxiety scores of one standard deviation or higher as measured by the trait portion of the State-Trait Anxiety Inventory were randomly assigned to either a RSA condition, a relaxation condition, or a control condition. Full data was available for 35 students. Both the RSA and relaxation groups attended two sessions of 1½ hours each. Post tests were given one to three months after the sessions. It was found that RSA was significantly more effective than relaxation ($F(2,32)=5.28, p<.025$) and significantly more effective than the control group ($F(2,32)=18.55, p<.001$) in the reduction of trait anxiety. It was concluded that for clients with a large degree of internalization and introspection, such as college students, RSA is a more effective self-directed technique than relaxation in the reduction of anxiety and should be utilized more extensively in the college setting.

PRELIMINARY STUDIES OF HUMAN STRESS BEHAVIOR WITH THE PSYCHOLOGICAL STRESS EVALUATOR. Michael P. Kradz* and John C. Bartone, American Health Research Institute, Annandale, Virginia 22003.

The Psychological Stress Evaluator (PSE) is a new instrument on the scene of science and horizon of medicine. Publications are rare. Unpublished research is spreading but remains devoid of peer supervision. Controversy concerns the PSE, as any new instrument that must gain universal approval. Stress, medical and psychic, in subjects contributes vast complications which worsen with different behavioral patterns and attitudinal development.

The PSE principally records sub-sonic vocal vibrations of the stressed or non-stressed vocalis muscle of the human larynx.

High stress factors (forgery, drugs, larceny and homicide) were tested in order to examine the reliability of the PSE and validity of suspects' data. Selected criminal cases, chosen to serve as controls provided dual causal relationships: (1) high human stress and (2) proven criminalistic and forensic data yielding definitive suspects' guilt which enhanced stress and removed all doubts of innocence of suspects. Proved guilt provided positive control data for these experiments. Comparably, the PSE herein offers a valuable (diagnostic?) aid for analysis of high stress crime and behavior of suspects.

THE EFFECTS OF KAINIC ACID LESIONS OF THE AMYGDALA ON EATING AND DRINKING. Paul A. Nathan*. Sponsor: L.E. Jarrard. Dept. of Psychology, Washington & Lee Univ., Lexington, VA 24450

The activity of the amygdala is of paramount importance in determining what the animal will and will not eat. Studies indicate that lesion removal of the amygdala causes the animal to be less neophobic about most learned things including comestible and libatious substances. The lesioning technique employed involved the use of kainic acid (KA). KA was used because of its excitotoxic ability to destroy nuclei rather than the fibers that pass through or terminate in the area; consequently, more specific lesions are possible.

The experiment tested four experimental and four matched, sham operated control rats. Their eating and drinking behavior relative to rat chow vs. sugar cookies vs. saltines vs. onion crackers and water vs. 0.05% saccharin solution were measured. KA (0.20 µg) was bilaterally administered over a fifteen minute period. The water consumed in the rat's home cage was also measured. Results suggest that amygdaloid removal via KA increases the frequency and amount of eating novel foods. The experimentals also showed greater preference for the saccharin solution over tap water. There were no differences in the amount of water consumed in the home cage. These results suggest that damage to the "fibers of passage" does not account for previous results and thus implicate the amygdala as being important in basic consummatory behaviors.

THE "REFLECTIVE" DREAM THEORY: AN ANALYSIS OF THE RELATIONSHIP BETWEEN TRAIT ANXIETY AND FREQUENCY OF ANXIETY DREAMS. Paul W. Stairs*, and Kenneth A. Blick. Dept. of Psychology, Univ. of Richmond, Richmond, Va. 23173

The purpose of the experiment was to test the continuity between personality traits exhibited during wakefulness and manifest dream content. The correlation between percentile scores of a trait anxiety scale and the incidence of anxiety as reported in dream diaries submitted by 31 undergraduates was found not to be significant. A frequency analysis of the emotional content of 155 dreams revealed no significant sex difference; however, certain emotions appeared significantly more often than others. Interest, fear, surprise, and enjoyment accounted for the majority of the emotions reported. Although no direct evidence was established to support the reflective theory, a format for the study of the emotional content of dreams was delineated.

ATTEMPTS TO ENHANCE RESIDENTIAL ENERGY CONSERVATION: ATTITUDINAL VERSUS BEHAVIORAL IMPACT. H. P. Wheeler*, K. L. Larson*, J. F. Ferguson*, and E. S. Geller. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

An interdisciplinary team of professors and students at VPI & SU has been evaluating, implementing, and promoting large scale procedures to increase energy conservation in community settings. This Community Education Model for Energy Conservation (CEMEC) is an ongoing HEA Title I project which began in the Spring of 1977, and combines expertise from architecture, physics, education, civil engineering, and psychology to develop and evaluate strategies for conserving energy. During 1977 and 1978, CEMEC organized and delivered educational workshops covering such topics as space conditioning, insulation, water heaters, and behavioral strategies for energy conservation, and assessed the attitudinal and behavioral impact of these workshops. CEMEC designed and implemented energy conservation workshops for three sectors of the community (consumer, commercial and governmental) regarding three major targets for energy consumption (transportation, buildings and equipment) with two basic strategies: physical (i.e., engineering technology) and psychological (i.e., behavioral science). In general, these workshops both increased public awareness as to the seriousness of the energy shortage, and changed participants' energy attitudes/opinions in the targeted directions; but field assessment indicated minimal behavioral effects.

ADAPTATION TO DELAYED VISUAL FEEDBACK WITH NON-DELAYED PROPRIOCEPTIVE AND VISUAL FEEDBACK TRAINING TRIALS. M. E. Witherspoon*, Child Develop. Ctr., Lynchburg Training Sch. and Hosp., Lynchburg, Va. and A. V. E. Harris, Department of Psychology, Radford College, Radford, Va. 24142.

This research examined motor tasks performed under conditions of delayed visual feedback (using a delay of 4.6 sec.). Prior experience with similar and dissimilar feedback conditions was given. Seventy (70) right-handed female undergraduate college students were given either 5, 10, 20 or no prior trials with a six-pointed star maze task in which each subject received either visual-proprioceptive or proprioceptive-only feedback. All subjects then performed a maze drawing task in a blind performance condition with either delayed or non-delayed televised visual feedback presented concurrently with each attempt. No adaptation to delayed visual feedback was observed, except for a significant difference in performance times for subjects who received different amounts of only proprioceptive feedback. On the basis of the data collected, it was concluded that timing factors are a critical factor in the control of visually monitored movements. The roles of visual and proprioceptive feedback in the control of such movements remains undetermined. Possible explanations for the absence of observable adaptation are discussed.

Space Science and Technology

Fifty-seventh Annual Meeting of the Virginia Academy of Science

May 8-11, 1979, University of Richmond

THE SPACE SHUTTLE PROGRAM. James P. Arrington,* Assistant Head, Vehicle Analysis Branch, NASA Langley Research Center, Hampton, Va. 23665.

The NASA has been developing the Space Shuttle as a reusable space transportation system for the past several years, and the first orbital vehicle, the Columbia, is presently being made ready for its first flight into space. A brief overview of the Shuttle Program will be given which will include a description of the Shuttle components; a general overview of the program management; a brief history of the orbiter 101, the Enterprise, that will include a movie describing the ferry and the approach and landing tests; and the status of the orbiter 102, the Columbia. The unique features of the Shuttle will be emphasized during a review of the mission profile which highlights the role of each component of the system. Emphasis will be given to the variety of payloads that will be delivered into near-Earth orbit. In particular, the benefits that can result from having easy access to space will be highlighted.

THE ROLE OF METHANE ON STRATOSPHERIC WATER VAPOR DISTRIBUTION. T. E. Augustsson* and S. N. Tivari. Dept. of Mech. Engrg. and Mechanics, Old Dominion Univ., Norfolk, Va. 23508

Theoretical considerations suggest that for each methane molecule (CH_4) that is completely oxidized one carbon dioxide molecule (CO_2) and two water vapor molecules (H_2O) result. In situ measurements in the stratosphere have shown that the mixing ratio of water vapor is approximately twice that of methane. A time-independent one-dimensional tropospheric-stratospheric photochemical model has been utilized to investigate a potential chemical link between methane and water vapor. The photochemical model is coupled with a one-dimensional radiative-convective model that calculates the atmospheric temperature profile since both carbon dioxide and water vapor are thermally active species. In addition, increased stratospheric water vapor will decrease stratospheric ozone (O_3) via the HO_x catalytic cycle. Calculations indicate that there is a moderately strong link between methane and water vapor in the stratosphere. Oxidation of methane does increase the concentration of water vapor molecules, but below the expected rate.

PYROELECTRIC DETECTORS FOR SPACEBORNE POLLUTION MONITORING. Ivan O. Clark*. Flight Electronics Division, NASA, Langley Research Center, Hampton, Va. 23665

An overview is presented of some of the current needs for spaceborne pollution monitoring. Emphasis is placed on the role of infrared spectroscopy in meeting the remote sensing requirements for determining atmospheric constituents from a spaceborne platform. Relevant spectral response data are presented for some commercially available infrared pyroelectric detectors over the range of 2.5 to 14 microns.

NASA RESEARCH TO IMPROVE AIRPORT CAPACITY, AIRWAY EFFICIENCY AND FLIGHT SAFETY. Leonard V. Clark.* Terminal Configured Vehicle Program Office, NASA Langley Res. Ctr., Hampton, VA 23665.

Several major airports in the U.S. are presently operating at or near maximum capacity throughout most of the day. Landing and takeoff delays at such airports are costing the air carriers and their customers enormous amounts of money, time, and scarce natural resources (fuel). With the prospect for construction of new major airports quite small in the foreseeable future, and with the rapid growth of air travel, especially since recent deregulation, the situation is continuing to worsen. Because of the important contribution that air transportation makes to our national economy, industry and government are working cooperatively to significantly improve the efficiency of the National Airspace System.

The NASA is engaged in a variety of research with objectives to develop and demonstrate improved airborne systems and operational flight procedures which can lead to increased airport capacity, airway efficiency, and flight safety. The Terminal Configured Vehicle (TCV) Program, a focal point for much of this activity, operates a specially configured B-737 airplane as a flying laboratory to conduct its research and development with particular emphasis on the terminal area environment. The TCV Program is dedicated to providing the flight crew with the advanced airborne systems necessary for it to conduct safe and efficient flight in an increasingly demanding environment.

A METHOD FOR GENERATING MISSION SPECIFICATIONS FOR REMOTE OBSERVATION SPACE PLATFORMS. W. T. Davis* and I. S. Keafer*, NASA, Langley Research Center, Hampton, Va. 23665

As part of NASA's space system research, several studies of large space platforms have been conducted recently. Platforms, as opposed to conventional satellites, can provide opportunities for synergistic application of several large experiments. Determining the proper experiment/instrument manifest and the associated orbital parameters, e.g., defining the mission specification, are difficult problems involving the matching of knowledge or information requirements to measurement techniques and capabilities for the various space operational modes. The approaches to mission specification used in the various platform studies are described briefly, as well as a new approach to the development of an interactive computer-aided technique. This unique capability can be an effective tool for study of future spacecraft concepts. The application of this technique as an approach to the development of mission specifications for a circa 1995 data acquisition platform for Earth resources and environmental information is described.

SF₆ CONDENSATION IN SUPersonic NOZZLE EXPANSIONS. S. S. Fisher, School of Engineering and Applied Science, University of Virginia, Charlottesville, Va. 22901.

The condensation of SF₆ in a dilute mixture with either Ar or He when expanded through a small, adjustable nozzle has been investigated. Condensation is observed by monitoring the disappearance of individual rotational-state lines in the infrared absorption band of SF₆ at 16 μ m. A diode laser spectroscopy system is used for this purpose. Condensation onset is studied as a function of local temperature, expansion rate, and SF₆ concentration. A simple, newly developed kinetic model is used to interpret and correlate the data.

COMPUTER SIMULATION OF LIQUID DROPLET FORMATION AND GROWTH IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL. R. M. Hall, Aeronautical Res. Scientist, NASA Langley Res. Ctr., Hampton, Va. 23665

The onset of condensation effects in the Langley 0.3-meter transonic cryogenic tunnel has been linked to the presence of liquid nitrogen seed droplets in the flow. These droplets originate at the liquid nitrogen injection station in the tunnel and evaporate as they are carried around the tunnel circuit. At some temperature approaching the saturation temperature, however, the droplets will not be able to completely evaporate by the time they are swept into the test section. The present talk describes the efforts at Langley to develop a computer program to model the injection process involving the breakup of the injected liquid nitrogen into droplets, the evaporation of the droplets during their transit time to the test section, and the condensation produced in the test section as a result of the surviving droplets. The results of the computer program are then compared to wind tunnel data and conclusions are drawn.

MEASUREMENTS IN A WAKE BOUNDARY LAYER INTERACTION FLOW FIELD AT MACH 6. Floyd G. Howard*, Aerospace Engineer, NASA Langley Res. Ctr., Hampton, Va. 23665.

One major obstacle to the development of advanced computational aerodynamic design tools is inadequate turbulence modeling for complicated viscous flows. Improved modeling requires precise three-dimensional fluctuating and mean measurements which are of questionable accuracy when obtained with conventional techniques (i.e., hot-wire, pitot and static probes, etc.). A program is currently underway at Langley Research Center to develop a Laser Doppler and Raman Scattering flow measuring system to obtain the type of data required for these improved turbulence modeling considerations. Since definitive results from this measuring technique are still at least a year or two away, traditional types of flow field measurements are being conducted in complex flows to provide data useful for checking the mean Laser Doppler Velocimeter data as well as for testing current computational fluid dynamic tools.

The present paper discusses results of one such experimental investigation in a complicated hypersonic viscous flow field. Surface and flow field characteristics measured downstream of a cylindrical wake generator positioned normal to and attached to a flat plate will be presented and discussed in detail with emphasis on the development of the turbulent shear layer downstream of the generator.

EXPERIMENTAL STUDY OF DELTA WING LEADING-EDGE DEVICES FOR DRAG REDUCTION AT HIGH LIFT.

D. M. Rao*, Research Professor and T. D. Johnson, Jr.*, Graduate Student, Mechanical Engineering and Mechanics Department, Old Dominion University, Norfolk, Va.

Supersonic aircraft with highly swept wings suffer large drag increment in low speed, high angle-of-attack flight due to flow separation at the leading edges. Control of leading-edge separation would permit higher lift coefficients for a given engine thrust, resulting in improved low-speed performance.

Various leading-edge devices (viz. fences, under-wing vortex generators, sharp extension plates, and open slots) applied to a 60° swept delta wing model with rounded leading edges were investigated in the NASA Langley 7-by 10-foot wind tunnel at low speed and up to 28° angle of attack. Force and pressure data were acquired along with flow visualization pictures.

All the devices were successful to varying degrees in reducing the drag of the plain wing at higher lift coefficients. The relative merits of the devices and their aerodynamic functioning are examined in terms of the spanwise distribution of leading-edge thrust, supplemented by the flow visualization results. (Supported by NASA Grant NGR 47-003-052).

ANALYTIC STUDY OF A TRUE AIRSPEED INDICATOR. J. Y. C. Shen*, J. M. Kuhlman, and G. L. Goglia, Dept. of Mechanical Engineering and Mechanics, Old Dominion Univ., Norfolk, Va. 23506.

A three-dimensional, inviscid, unsteady, incompressible flow has been studied in a vortex tube by using the hydrodynamical linearized stability theory. Disturbances caused by the sudden enlargement at the rear end of the vortex tube grow exponentially in time, and when amplified to a certain degree give a definite whistle at a frequency which is linearly proportional to the true airspeed.

The objective of this study is two-fold. The first objective is to analyze and design a true airspeed indicator which will replace the conventional pitot-static pressure transducer for small commercial aircraft. The second objective is to obtain a numerical solution to predict the frequency response generated by the vortex whistle indicator at a certain airspeed.

The main advantage of this indicator is that the flow phenomenon, precession of the vortex, which causes the vortex whistle, needs no moving parts. In addition, this indicator should not be affected by temperature, density and humidity changes. (Aided by NASA grant NSG 1177)

AEROSPACE SCIENCE AND TECHNOLOGY IN THE USSR. M. Leroy Spearman*, Aerospace Engineer, High-Speed Aerodynamics Division, NASA Langley Research Center, Hampton, VA 23665.

The USSR considers science and technology as a major constituent to a world revolutionary process of transition from capitalism to communism. Scientific and technological advances are related directly to the economic growth of the state. Accordingly, the USSR shows a great concern for the development of modern education with heavy emphasis on science, technology, and cultural attainments. A review of the educational system is given and some of the technological results, particularly as seen in the emergence of powerful air, land, and sea forces, are highlighted. Some observations are made concerning Soviet design philosophy, some accomplishments, and possible future goals.

EFFECTS OF NOSE BLUNTING ON FLOW PHENOMENA AROUND A JOVIAN ENTRY BODY. S. V. Subramanian*, S. N. Tiwari, Dept. of Mechanical Engineering and Mechanics, Old Dominion Univ., Norfolk, Va. 23508, and K. Sutton*, NASA/Langley Research Center, Hampton, Va. 23665.

The effects of changes in the probe configuration on flow phenomena around a Jovian entry body is investigated. Results were obtained for inviscid radiating shock-layer gas under the assumptions of chemical equilibrium. The initial body shape considered was a 45-degree sphere cone. Different configurations for the forebody of the entry probe were considered to represent the shape change due to ablation. The results indicate that while the nose blunting increases the temperature all along the body surface, its influence on increasing the density is significant only in the stagnation region. This, in turn, results in higher stagnation region and downstream pressures. Uniform mass loss resulting in a shape that corresponds closely to the initial profile does not affect the temperature, density, and pressure distribution along the body appreciably. The shock stand-off distance is found to increase with increasing bluntness of the nose. Severe nose blunting is seen to increase the stagnation region radiative heating of the body. Density and velocity variation along the stagnation stream are not influenced by profile changes. However, in the downstream region, density and velocity variations across the shock layer are altered significantly by the probe configuration changes.

FREE-JET KINETIC DISTRIBUTIONS MEASURED BY AN ELECTRON-BEAM-INDUCED FLUORESCENCE TECHNIQUE. P. J. Wantuck* and S. S. Fisher, School of Engineering and Applied Science, University of Virginia, Charlottesville, Va. 22901.

An apparatus has been developed which is used to measure density distributions in free-jet expansions of gases into a vacuum. Densities are measured by passing a beam of high-energy electrons through the jet and recording the fluorescence stimulated in the gas by the passage of this beam. At lower gas densities, this fluorescence is linearly proportional to the density of the gas. This apparatus has been used to investigate both CO_2 and UF_6 expansions. In either case, the large flow rates encountered are pumped cryogenically. These expansions are examined as a function of both nozzle Reynolds number and nozzle geometry. Fluorescence is measured photographically and density distributions are determined by sweeping the electron beam along the jet axis.

Statistics

Fifty-seventh Annual Meeting of the Virginia Academy of Science
May 8-11, 1979, University of Richmond

ESTIMATING RELATIVE POTENCY FROM THE HYPERBOLIC DOSE-RESPONSE MODEL. J.T. Crowe, Jr., A.H. Robins Co., Richmond, VA 23220.

The fundamental dose-response function for many pharmacological and toxic agents can be derived from the assumptions of Receptor Theory and the Law of Mass Action. This function is the rectangular hyperbola, $y = Y_{\text{md}} / (K + d)$, where y is the response, Y_{md} the maximum response, d the dose and K is equivalent to the median effective dose (ED_{50}). If two drugs have the same maximum response, an estimator, $R = K_2 / K_1$, can be derived which expresses the relative potency of a test drug, T , to a standard, S . This paper presents the derivation and properties of the estimator, R .

A COMPARISON OF CERTAIN REGRESSION ESTIMATORS IN THE PRESENCE OF NON-HOMOGENEOUS VARIANCES. M. L. Deaton*, M. R. Reynolds, and R. H. Myers. Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

The problem of estimation and hypothesis testing for the general linear model with unknown heteroscedastic variances is considered. Ordinary least squares estimators of the regression coefficients are compared with weighted least squares estimators using estimated weights. Empirical results provide sufficient conditions for weighted least squares to have smaller MSE than ordinary least squares estimates.

Alternative estimates for the variance-covariance matrix of the coefficient estimators are compared. First and second moments are provided for some variance estimators. Recommendations for which estimator to use are provided.

The usual test statistics for the general linear hypothesis are shown to deviate from the F - or χ^2 -distributions that are often used in practice when using ordinary least squares or when the error variance matrix is known. A good approximation to the distribution of these test statistics is given. (Aided by NASA grant NSG1376)

APPROXIMATE COMPARISONS OF TWO BINOMIAL POPULATIONS.

B. K. Ghosh. Dept. of Mathematics, Lehigh University, Bethlehem, PA 18015, and Dept. of Statistics, VPI&SU, Blacksburg, VA 24061.

Suppose that p_1 and p_2 are the unknown proportions of success in two binomial populations. The following problems arise quite frequently in practical situations:

(a) test the hypothesis $p_1 = p_2$ against $p_1 \neq p_2$ at a given level of significance; (b) test $p_1 \leq p_2$ against $p_1 > p_2$ at a given level; and (c) construct a confidence interval for $p_1 - p_2$ with a given confidence coefficient. This paper gives a comparative study of three well-known approximate test procedures for each of (a) and (b). Extensive numerical results are obtained on the type one error probability and power of these tests. The paper also investigates into the adequacy of a well-known approximate confidence interval for the problem in (c).

FACTORIAL EXPERIMENTS WITH POISSON RESPONSE VARIATES. The DISTRIBUTION THEORY FOR EXACT TESTS. A.D. Harris*, Dept. of Math., Va. State Col., Petersburg, VA 23803, W. H. Carter, Dept. of Biostat., Med. Col. of Va., Richmond, VA 23298.

Recent research has indicated that the micronucleus test is a relatively quick and easy way of measuring the carcinogenicity of compounds. Research also supports the assumption that the frequency of micronuclei are Poisson distributed. It, therefore, seems reasonable to suppose that a statistical procedure which would test for interaction in a factorial experiment where the response variates are Poisson could be applied to micronuclei data for the purpose of testing for interaction among potential carcinogens.

Such a procedure is developed based on the conditional distribution of Poisson random variables. The necessary distributions are derived and a method for performing tests on interaction in 2^k factorial experiments with Poisson response variates is described. The tests are based on the exact distribution of the test statistics. A procedure for analyzing fractional factorial experiments is also developed.

A normal approximation to the exact distribution of the test statistic is given. The results of simulation studies to measure the adequacy of the normal approximation under various conditions are presented.

Finally, a formula for computing the power of the normal approximation against specific alternatives is given.

GENERATING MATRICES OF WISHART'S TYPE. D. R. Jensen and Y. V. Hui. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Three methods are compared for generating pseudorandom noncentral Wishart matrices. These include a direct method, a modified convolution method, and a block composition method. Applications are noted in assessing the accuracy of approximations to the joint distributions of certain functions of the elements of Wishart matrices, and in constructing multiple tests at level α using Friedman's statistics when their limiting joint distribution depends on parameters of the underlying distribution.

CREDIBLE CONJECTURE OR SCIENTIFIC TRUTH. Marvin A. Kastenbaum*, Ph.D., The Tobacco Inst., 1776 K Street, N.W., Washington, D. C. 20006.

In January 1978 the Food and Drug Administration announced that from April 1978 on, all oral contraceptive labelling would carry a highlighted notice warning users against cigarette smoking. This decision, the FDA alleged, was based on sound scientific and statistical evidence. Nevertheless, several independent, competent statisticians who examined the same evidence found that the FDA conclusions were questionable.

THE MAX VARIANCE RATIO IN EXPLORATORY DATA ANALYSIS. D. V. MATHUSZ, Operations Research Division of USALOGC, Ft. Lee, VA. 23801

Exploratory Data Analysis is investigative in nature and as such, its procedures involve graphic displays of the structure of data. Selection of these graphic devices are primary tasks for the researcher. To aid in these decisions, a simple index has been designed to measure the amount of clustering at the range extremes or it's opposite, i.e., a center cluster whose range is defined by "outliers." This index is the MAX Variance Ratio (MVR). It is the ratio of the variance of the data divided by the maximum variance possible for "n" data points, free to take any value set over the same range, with the same number of points. This MVR has a normalized scale of zero to unity. The MVR can be divided by a Neutral Variance Ratio (NVR), that defines when the aggregate clustering at the range extremes reverts to the opposite. It is shown that the MAX Variance for even n is $R^2/4$, but that for odd n is $f(R,n)$ which converges asymptotically toward the value for even n , as n increases. It is also shown that in the limit NVR is $1/3$ of $R^2/4$. Tables and graphs are provided for small n not close to the limiting values. The index is demonstrated in a classic example.

THE PROCESS & OUTCOMES OF THE VIRGINIA HEALTH INTERVIEW SURVEY. Frank H. Mays*, Southwest Virginia Health Systems Agency, Blacksburg, Va. 24060

In Sept. 1977, the five hlth. systems agencies (HSAs) and State Health Dept. pooled funds for a statewide hlth. interview survey to obtain detailed information on family hlth. status, life styles, and patterns of use of the hlth. care system among Va. families. Research Triangle Inst. was selected as primary contractor; the Director of Va. Ctr. for Hlth. Stats. served as coordinator; and the Va. Hlth. Interview Council (with the author as Chairman) was formed to direct the project and give final approval to written project reports. A contract specification was for a sample size where data collection and analysis would be provided for five (5) distinct subdomains of an estimated 1000 households each to facilitate comparative analysis among Va. regions and to highlight regional differences. The sample design was primarily in 3 stages, with stratification imposed at 1st stage to control sample distribution with respect to geography, level of urbanization and relative socioeconomic position. OUTCOMES: There was a yield of 5,617 eligible household units to be surveyed; interviews were completed in 5,069 households with an overall response rate of 90.4%. The refusal rate was 4.5%. Statewide estimates can now be made on variety of health status and use measures with a coefficient of variation (CV) generally less than 10%. Health care planners now have a data set on families which represents a significant contribution to knowledge.

SIGNAL CLASSIFICATION BASED ON EMPIRICAL DISTRIBUTIONS OF ZERO CROSSINGS. James R. Schless*, NASA, Langley Research Center, Hampton, VA 23665.

In the absence of a non-zero waveform, digital signals are zero mean random error. For this reason the number of times the recorded signal crosses the zero axis is related to the presence of a signal. Probability distributions are fit to crossing counts over subintervals of the signal and used in Bayes' theorem to derive a classification rule. The method is applied to EEG data to show the usefulness of this approach.

*Member, ASA

DECISION CONSIDERATIONS FOR COMBINATION CHEMOTHERAPY SURVIVAL EXPERIMENTS. Donald M. Stablein, Walter H. Carter, Jr., Dept. of Biostatistics, Med. Col. of Va., Richmond, VA 23298, G. L. Wampler, Dept. of Medicine, Richmond, VA 23298

The proportional hazard model provides a potentially useful procedure for the analysis of combination chemotherapy animal survival experiments. The design considerations for such experiments are complicated by the fact that maximum likelihood estimation of model parameters does not yield estimators in a closed form. Therefore, it is not possible to study their properties analytically. A simulation study has been undertaken to arrive at design criteria under the assumption of a relative hazard that is quadratic in the drug dosages administered. Different designs are evaluated with respect to their ability to locate the optimum and its associated response, as well as the variance and bias of the parameter estimates. Some interesting effects of singly censored data results.

ANALYSIS OF A NON-PROPORTIONAL HAZARD MODEL. Donald M. Stablein, Walter H. Carter, Jr., Dept. of Biostatistics, Med. Col. of Va., Richmond, VA 23298, G. L. Wampler, Dept. of Medicine, Richmond, VA 23298

The concern that hazard functions in cancer chemotherapeutic situations may not be proportional motivates the development of a non-proportional hazard model. Subsequent to its construction, the regression analysis of experimental data permits the application of response surface techniques. After the estimation of the underlying hazard function, the quality of the fit of the model is assessed. Further treatment levels may be optimized and estimated survival distributions plotted for any treatment combination. In an example of two drug treatment of murine L1210 leukemia, statistically significant non-proportionality is determined. Analysis permits extraction of potentially important information on drug inter-relationships which has been previously unavailable.

MODIFIED PRINCIPAL COMPONENTS REGRESSION: A MEAN SQUARED ERROR EVALUATION. H. T. Wu and J. W. White, Dept. of Statistics, Va. Polytechnic Institute & State Univ., Blacksburg, Va. 24061

When Principal Components Regression is used as an alternative to Least Squares in the presence of a near singular $X'X$ matrix its performance depends strongly on the orientation of the deleted components to β , the vector of unknown regression coefficients. In this paper we present a modification of the Principal Components Procedure in which components associated with near singularities are dampened but are not completely deleted.

The resulting estimator was compared in a Monte Carlo study with Least Squares and Principal Components using Mean Squared Error as the basis of comparison. The results indicate that the modified estimator will perform better than either of the other two estimators over a wide range of orientations and signal-to-noise ratios and that it provides a reasonable compromise choice when the orientation is unknown.

THE APPLICATION OF RELIABILITY THEORY IN BIOSTATISTICAL STUDIES. S. Zacks, Department of Mathematics and Statistics, Case Western Reserve University, Cleveland, Ohio 44106

Reliability theory embraces various branches of probability and statistics applied towards the modeling, analysis of the structure and the inference of the survival probabilities of complex systems. Traditionally, reliability theory has been oriented toward engineering systems. Applications in biostatistical studies address similar problems on biological systems. In the present paper we focus attention on three areas of applications in biostatistics:

- (i) Survival functions and remaining life distributions of patients;
- (ii) Tolerance distributions and the determination of optimal dosages;
- (iii) The problem of "safety-dosages".

APPLICATION FOR MEMBERSHIP
VIRGINIA ACADEMY OF SCIENCE

Box 8454, Richmond, Virginia 23226

Name (Please Print) _____

Address (P.O. Box or Street) _____

City State Zip

Institution or Business _____

Position - Title _____

Field of Interest, Section No. _____

Date _____ Class of Membership Desired  _____ Contributing _____ Sustaining
_____ Regular _____ Student
_____ Business

Contacted by: _____

Make check payable to VIRGINIA ACADEMY OF SCIENCE and send to above address.

MEMBERSHIP

The Academy membership is organized into sections representing the various scientific disciplines.

Addressograph plates of all members are coded by number. The First Number indicates the member's section and enables Section Officers to more easily contact members.

- | | |
|-------------------------------------|---------------------------|
| 1. Agricultural Sciences | 9. Medicine |
| 2. Astronomy, Mathematics & Physics | 10. Psychology |
| 3. Microbiology | 11. Education |
| 4. Biology | 12. Statistics |
| 5. Chemistry | 13. Space Science |
| 6. Materials Science | 14. Botany |
| 7. Engineering | 15. Environmental Science |
| 8. Geology | |

Annual Membership Dues

Approved March 18, 1973

Business	Includes subscription to Virginia Journal of Science
Sustaining
Contributing
Regular
Students

*\$25 or more.

The world of biology at your fingertips!

Biological Materials



0/1979-80

Carolina Biological Supply Company

Carolina's New 1979-80 Catalog of Biological Materials

gives you easy access to thousands of
interesting and innovative top-quality
teaching materials.

Request your free copy today!

Carolina Biological Supply Co.
2700 York Rd.
Burlington, North Carolina 27215

Please send me a free 1979-80
Carolina Catalog 50.

Name _____

Institution _____

Address _____

City _____

State _____

Zip _____

Carolina Biological Supply Company

2700 York Road
Burlington, North Carolina 27215

Box 7
Gladstone, Oregon 97027

505.73
V81

VOL. 30, NOS. 3 & 4
FALL & WINTER 1979

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE



THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware
Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer
Box 637
Lancaster, Virginia 22503

SECTION EDITORS

Agricultural Sciences

R. J. Stipes
417A Price Hall
VPI & SU
Blacksburg, Va. 24061

Physics

Dr. W. Peter Trower
Dept. of Physics
VPI & SU
Blacksburg, Va. 24061

Biology

Patrick F. Scanlon
Dept. of Fisheries & Wildlife
VPI & SU
Blacksburg, Va. 24061

Botany

David A. Breil
Dept. of Natural Sciences
Longwood College
Farmville, Va. 23901

Chemistry

Roddy G. Bass
Dept. of Chemistry
Va. Commonwealth Univ.
Richmond, Va. 23284

Education

C. Dillard Haley
Dept. of Education
900 Fairfax St.
Radford, Va. 24141

Engineering

Walter R. Hibbard
301 Holden Hall
VPI & SU
Blacksburg, Va. 24061

Environmental Sciences

Michael Garstang
Dept. of Env. Science
Univ. of Virginia
Charlottesville, Va. 22904

Geology

Roddy V. Amenta
Dept. of Geology
James Madison Univ.
Harrisonburg, Va. 22801

Materials Science

John C. Duke, Jr.
Dept. of Eng. Sci. & Mechanics
VPI & SU
Blacksburg, Va. 24061

Medical Sciences

Charles O'Neill
Dept. of Biophysics
MCV
Richmond, Va. 23298

Microbiology

Paul V. Phibbs, Jr.
Dept. of Microbiology
MCV-VCU
Richmond, Va. 23298

Psychology

Frank S. Murray
Psychology Dept.
Randolph-Macon Women's College
Lynchburg, Va. 24503

Space Science & Technology

Sam S. Fisher
Dept. of Mechanical and Aero-Space
Engineering
Thorton Hall, Univ. of Va.
Charlottesville, Va. 22901

Statistics

J. Van Bowen, Jr.
Dept. of Mathematics
Univ. of Richmond
Richmond, Va. 23172

©Copyright, 1980 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P.O. 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia and additional entry at Harrisonburg, Virginia 22801. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1980: \$15.00 per year, U.S.A.; \$20.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$4.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send address changes to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper (8½ × 11 inches). Margins should be not less than 1½ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and

affiliation, and proposed running title, all appearing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year-format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and *first and last* page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. Metamorphic Textures. Pergamon Press, New York. 350 pp.

Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians, Part III. Vertebrates* (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 30

Nos. 3 & 4

Fall and Winter 1979

TABLE OF CONTENTS

EDITORIAL

ARTICLES

The Sydney S. Negus Symposium: The Commonwealth—Science Education and Technology	115
Statewide Survey of Psychology Majors in Virginia: Class of 1978. <i>Frederick B. Rowe</i>	123
Geometrical Optics of Planar Interfaces. <i>E. F. Turner and H. T. Williams</i>	128
Response of Aggressive and Non-Aggressive Isolates of <i>Ceratocystis ulmi</i> to Benzimidazole Carbamate Fungitoxicants <i>Delano B. Janutolo and R. Jay Stipes</i>	132
Obituaries:	135
William Miller Hinton	
Esmarch Senn Gilreath	
List of Members	136

EDITORIAL

The Editor and Business Manager of the Virginia Journal of Science were instructed by the Publications Committee of the Virginia Academy of Science to combine under one cover the last two issues of Volume 30 (1979) of the Journal, so that the effort to get the Journal back on schedule could be speeded up. Thus, this printing of the Journal is counted as combined Fall and Winter issues. The publications committee also strongly advised that this policy be continued into Volume 31 (1980), and we intend to follow their advice. Thus, the next printing will be Volume 31, Issues 1 and 2, under a single cover. Issue 3 of 1980 will be the Proceedings issue, which should place the Journal back on schedule.

The Editor wishes to express his appreciation to the Publications Committee, the Council and the Executive Committee of the Academy for patience and support during the year-long transition period between editors, and especially to former President Dale Ulrich, whose moral support has been unflinching.

Business Manager Kizer has labored long and hard to attract advertising, and the Editor urges all business members and readers who are officers of businesses to respond heartily to Mr. Kizer's efforts.

Members should remember the journal welcomes submitted manuscripts. A good journal must have good papers. Please help us by sending more of those good manuscripts we need.

The Commonwealth - Science Education and Technology The Sidney S. Negus Memorial Symposium

Fifty-Seventh Annual Meeting of the Virginia Academy of Science

May 10, 1979

Camp Theatre, University of Richmond

Participants:

Dr. E. Bruce Heilman, *President, University of Richmond*
Moderator

The Honorable Maurice B. Rowe, *Secretary of Commerce and Resources, Commonwealth of Virginia*
The Role of State Government in Science and Technology and the Role of Science and Technology in State Government

Dr. W. E. Campbell, *Superintendent of Public Instruction, Commonwealth of Virginia*
The Role of Elementary and Secondary Education

Dr. Frank L. Hereford, Jr., *President, University of Virginia*
The Role of Higher Education - Undergraduate and Graduate

Dr. Helmut R. R. Wakeham - *Vice-President for Science and Technology, Philip Morris, Inc.*
Industry - Its Needs and Expectations

The Role of State Government in Science and Technology and the Role of Science and Technology in State Government

The Honorable Maurice B. Rowe

Secretary of Commerce and Resources
Commonwealth of Virginia

In recent decades we have come to realize the ever increasing importance of science and technology in solving critical problems and in enhancing our quality of life. (The mid-sixties saw the manned moon landing as the symbol of technological achievement, and in the field of social problems, the federal great society programs were a similar massive effort.)

In the early seventies, environmental health and ecological problems gained increasing significance, in part as the result of improved environmental monitoring techniques. Emerging from this convergence of events was a renewed belief on the part of many government officials and others that science and technology would have a significant role in developing solutions to social and environmental problems, particularly those faced by state and local governments.

In Virginia state government has recognized the value of science and technology in defining problems and evaluating possible solutions. State agencies across each area of cabinet responsibility have developed and

implemented programs based on the application of science and technology, much of which has been provided by institutions of higher education.

Within the Office of Commerce and Resources, agencies such as the State Water Control Board, Marine Resources Commission, Department of Conservation and Economic Development, and the State Air Pollution Control Board are involved daily in both monitoring the quality of our air, water, and land resources and in managing the use of these resources.

Basic and applied research conducted by the institutions represented by many of the members of this academy is utilized by government and private industry on a daily basis in making resource management and business decisions.

Technology of benefit to state agencies and by local governments in satellite imagery of the earth, one of the most important practical application systems to emerge from the space program. Landsat, as this system is known, offers information of board economic

and environmental value through its ability to produce repetitive images of changing earth conditions. Landsat images can inventory watershed conditions, identify air and water pollutants, study urban growth patterns and detect agriculture problems.

Often the knowledge of data available from Landsat and more conventional sources of information are unknown to potential users. To deal with this problem, the Commonwealth is developing the Virginia Resource Information System as a means for integrating information from various sources for easy access to support analysis, evaluation and management decisions related to air, land, water, agricultural, and forest resources. When implemented this information system will offer many benefits to state agencies, academic institutions, and other interested potential users in Virginia. These benefits include:

- a. The provision of a single point of contact for statewide resource information without interfering with current data gathering activities, and
- b. The provision of a mechanism for assembling data from a variety of resources focused on a particular political, geographic or planning district boundary.

There are indeed many other examples of valuable technology transfer contributed by education and research institutions of our Commonwealth. In fact there is daily exchange of information by our science and technology community with program specialists of state government.

With due consideration of progress, the utilization of science and technology in government decision-making and policy-formulation process must be increased and refined. Since the late 1960's there have been formal and informal attempts to improve the communication between Virginia state government and the science, engineering, and technology community through the appointment of a Governor's Science Advisor and more recently through closer ties with the Virginia Academy of Science. Some of you are aware that the Commonwealth recently prepared a study sponsored by the National Science Foundation to analyze the state's decision making needs for further science, engineering and technology expertise and to devise a plan for responding to these needs. In late 1977 the division of legislative services and the department of intergovernmental affairs began studies for the legislative and executive branches, respectively. The results of the executive branch study reveal that there is a perceived need on the part of most members of the cabinet and in many state agencies for a central coordinative mechanism which would help decision-makers to identify sources of knowledge with specific expertise. There was a consensus that such a system should be flexible and serve primarily as a communication network. This will assist decision-makers in assessing options available for the resolution of policy issues and will assist the agencies in identifying applications of research knowledge to particular problems.

I am pleased to report the following initiatives on the part of the executive branch:

1. The Department of Planning and Budget will be vested with responsibility for activating the science advisory mechanism.
2. An existing position within the department will be assigned responsibility for the coordinative aspects of science and technology advice.
3. The department's efforts for the next several months will be, in essence, picking up where the study left off in such areas as:
 - a. Identifying resources/expertise available.
 - b. Developing an evaluation device to test the mechanism.
 - c. Testing the mechanism for validity refinement.

In exploring the ways for taking the fullest advantage of the relationship between science and technology and state government, we must be creative and innovative. The focus of this effort should not be to develop and foster the utilization of particular "solutions"—technologies, techniques or systems. Instead, we should work toward building the analytic and evaluative capabilities of state government. We must be careful of the temptation to institute attractive programs which promise to promote short-run, highly visible results. In short what matters is not only the adoption of an innovation, but how that innovation is used and how its adoption and use are linked to the satisfaction of a need or solution of a problem.

The Virginia Academy of Science has been effective and important organization for interfacing the scientific community with policy decisionmakers and advancing the interest and requirements for persons educated as professionals in the broad area of the sciences.

May I call upon you to continue to exert leadership to provide educational opportunities to enhance the professionalism for scientists and become more active in the mainstream of our society and economy to objectively mold public opinion.

The conditions prevailing today across our nation cause us to be very conscious of the tremendous need for scientific evaluation and for scientists to step forward and speak with authority.

We are much more conscious of risks which we encounter daily than people were 50 or even 25 years ago. This is not only because we are better educated, but also because news media brings to our attention much more information than was conceivable in former years. We really ought to be given an opportunity to compare the different risks around us before being put into a panic by those who lack scientific knowledge to speak with authority.

I would like to thank the Academy for its learned and valuable counsel, particularly most recently in the development of the National Science Foundation report. I urge you to assist in fostering closer ties between the scientific community and state government toward developing a more informed base for policy formulation in the executive and legislative branches.

The Role of Elementary and Secondary Education

(Outline of Comments)

Dr. W. E. Campbell

Superintendent of Public Instruction
Commonwealth of Virginia

Concerns and Problems

- I. Lack of scientific literacy on the part of too many of our citizens, including students and graduates.
 - A. Uninformed and not able to deal effectively with too many day to day decisions.
 1. Should I use a hair dryer? (Asbestos)
 2. Are the fish in the James River safe to eat? (Kepone)
 3. How dangerous are chemicals in our schools? (Picric acid)
 4. Should I favor nuclear power generation? (Three Mile Island)
 - B. Not able to distinguish between scientific evidence and personal opinion.
 1. With Crest I will get fewer cavities!
 2. Smoking won't affect my health!
 3. If I drive 70 miles per hour I get there faster and save gasoline!
 4. Modifications of weather produce only positive results!
 - C. Unmotivated to increase scientific knowledge throughout life.
 1. Lawyers have no need for scientific information.
 2. Just ask the "experts."
 3. Scientific facts are not subject to change.
- II. Much improvement needed to teach science more effectively.
 - A. Recent NSF study showed:
 1. Only 4% of classes in elementary science taught in special science rooms.
 2. More than one-third of instruction is done without special science equipment.
 3. In the secondary schools lecture and reading about science are most prevalent means of instruction.
 - B. Most students not drawn into science even in a nontechnical way.
 1. Fifty percent of the students take no science courses beyond tenth grade.
 2. Decline in students taking so-called "hard" subjects.
 - C. Many teachers are, or feel they are not well prepared to teach science, especially in elementary school.
 - D. Field trips and laboratory work not considered an essential part of the science program.
 - E. "Back to Basics" has cut into the time for science and other subjects.
- III. A Decline in Achievement
 - A. Achievement of 17 year olds has continued to drop through all assessments in science since 1969.
 - B. Appears to be a declining interest in and knowledge of science by nation's school children.
 - C. Steep decline in physical-science achievement.
 - D. SRA test scores have declined for eleventh graders in Virginia since 1970.
 - E. Lower socio-economic levels, females and residents of large cities tend to perform below national averages at fourth, eighth, and eleventh-grade levels in science achievement.
- IV. General Areas of Concern
 - A. Environmental-energy problems brought on due to lack of basic scientific knowledge.
 1. Lack of understanding about the interactions and inter-relationships of the physical and biological world.
 2. Lack of realization that high energy level economy demands trade offs for favorable environment.
 3. Lack of basic understanding of the finite nature of fossil fuels.
 - B. Failure to view science as a "basic" in this scientific-technological society.
 1. Science not viewed as a logical subject to teach knowledge application and transfer.
 2. Failure to view science as important component in the students' program can lead to future decline in technology.
 3. Subjects such as science can emphasize the "basics" (reading - arithmetic) by creating interest for many students.
 - C. Many science programs not relevant for general student population.
 1. Emphasis on dissection of the earthworm rather than subject of ecology.
 2. Over emphasis of *second* level programs rather than emphasizing such *first* level programs.
 3. Too little emphasis on programs for the non-science oriented student.

What Virginia is Doing

- I. Through Science Community Network developing better communications among Department of Education, colleges-universities, and local school divisions in order to develop statewide goals-objectives for science and work collectively to achieve these self-objectives.

1. Stresses articulation K-12.

2. Content of science focusing upon energy-environmental concerns.

Publications stress laboratory-field studies with emphasis upon the inquiry approval.

Taking a very serious look at requiring another year of science for meeting graduation requirements.

- II. Continue to emphasize science as a method of inquiring about the world rather than as a set of conclusions about it.

Requires special science rooms, special supplies and equipment and field experiences to be most beneficial.

Requires teachers who will use their special rooms, supplies and equipment and encourage students to probe for answers.

Requires teachers well trained in their subject matter and well trained to work with students in a manner that will help students understand.

Requires approaches that will encourage students to want to become involved in learning more about science.

State requirement that science be taught as a laboratory program, whereas some neighboring states are not.

Advises local school officials with regard to desirable types of science facilities. Science personnel of State Department reviews plans. Suppliers say Virginia still building laboratories.

Selects textbooks that reflect a more difficult approach to learning science.

Recent publications by the Department which stress laboratories and field trip experiences for students.

Required endorsements for all areas of science teachers.

Conduct workshops for teachers which stress laboratory and field trip experiences for students.

- III. A Better Assessment of What Achievement Scores Mean

Find answers to such questions:

Are the scores measuring what is currently being taught?

Are the test scores reflecting something other than science content?

Is the 17-year decline in achievement due to fact that fewer students are taking more than one year of science?

Are science programs relevant for the non-science oriented student?

Through the Science Communication Network to encourage local school divisions to urge students to take more than the required course in science.

About six divisions require two units. Fairfax and others are studying the matter.

In Summary

1. Development of Program Goals and objectives for science K-12.
2. Production of publications which stress science as inquiry.
3. Emphasis upon training and having more qualified teachers.

In this time of surplus in the teacher market more emphasis can and should be placed on assigning teachers to subject areas and student levels in which they are most qualified.

More coordination with the colleges and universities for preparation and continuous growth of science teachers.

4. Subject matter of science must be relevant for all levels of students, including greater emphasis on science education for the general students.
5. Encouraging earth science and environmental-energy types of courses, and middle school science program.

The Role of Higher Education - Undergraduate and Graduate

Dr. Frank L. Hereford, Jr.

President
University of Virginia

I am delighted to be with you this evening and to have the opportunity to comment on the role of higher education in science education and technology.

The first point I should like to make is that the role of higher education in science and technology is no different from its role in any other branch of knowledge. Actually, there are two roles—the dissemination of the existing body of knowledge and the gaining of new knowledge through research. It is generally recognized that colleges and universities also have a public service responsibility beyond teaching and research, but I believe that their concern with knowledge is and should be paramount.

There is a tendency to consider science and technology as different from other branches of knowledge, because applications of scientific knowledge so obviously translate into technology resulting in improvements in food production, medical care, radio and telecommunications, and in other areas which enhance the quality of life. However, this is true of every field of knowledge. Surely the human mind has exerted the most powerful single influence on the advance of civilization. But what would man's intellectual power be without the understanding of the past provided by scholars of history; or of political science, economics, and social systems provided by scholars in the social sciences; or of human values provided by scholars in the Humanities? There is a tendency to believe that new scientific knowledge gained through basic research has a more immediate impact on civilization, but I dispute this also. Radio and telecommunications today have derived in a continuing way from the research of James Clerk Maxwell, a British professor of physics, and other physicists in the mid-1800s—a century and a half have transpired.

Richard Feynman, the Nobel Prize-winning physicist, provided an interesting example some years ago of the media's tendency to over-emphasize the immediate application of scientific knowledge. New convincing evidence had been found of a rapid turnover of matter in the brain—the actual replacement of old atoms by new ones. Feynman's own words exhibit his flair and humor:

What is this mind, what are these atoms which have consciousness? Last week's potatoes! *That* is what now can remember what was going on in our mind a year ago—a mind which has long ago been replaced.

The headline of a news story on this discovery had stated "New Hope for the Cure of Brain Cancer"—

obviously a premature expectation. Feynman, however, sought to convey as I do now, simply the intriguing nature of the remarkable fact that our ongoing consciousness and the storage capacity of our brains reside not in some stable, unchanging piece of matter—such as a computer—but in some stable mode of biological interaction between transient bits of matter in the brain.

What good is this knowledge? What good is a History—or a sonnet? Each is simply an example of man's effort to understand the nature of the universe and to express his perception of his role in it. Surely this ongoing effort and man's excitement over it and dedication to it are the most distinctive characteristics of the human race.

These remarks bring into focus the particular role of higher education—as distinct from that of government or industry—which I believe does and should exist. Again its particular role is the gaining of knowledge and its dissemination—as distinct from putting it to use and applying it for the benefit of people or for the enhancement of our economic prosperity—which, of course, also benefits people.

However, this principal role is not absolutely exclusive. There is no sharp dividing line between pure knowledge and its application. Our universities do engage significantly in the use of new knowledge. Our professors of medicine seek new cures for disease when an understanding of the disease renders this feasible; our schools of engineering are committed to applied research; and the work of scholars in the social sciences and humanities helps society to make the best judgments on the priorities to be assigned to emerging technologies.

However, I believe that examination of these efforts will show that they are more at a level of understanding new knowledge than at a level of actually producing a new computer or mousetrap for the market. Certainly no faculty member would be distressed if a patentable idea or device emerged from his work, but I don't think that this would be cited as a primary motivation.

From the point of view of the general public, I suppose the most readily apparent contribution which higher education makes to science and technology is the production of highly trained and educated young men and women to continue the quest for knowledge and to put it to work for mankind. Let there be no doubt our our commitment to that task, but the teaching function of colleges and universities goes hand in hand with research. I cannot recall a faculty member who was able to sustain good teaching over a period of

years without remaining a student himself—and a researcher is a student. His investigative work gives him new insights, and keeps him excited. Whether teaching undergraduates or graduate students it is virtually impossible for a teacher to intrigue and excite students about a subject unless he himself is intrigued and excited. Furthermore, the students play a role by provoking a continuing reexamination of ideas and concepts on the part of an instructor. I have often heard physicists in our national laboratories such as Oak Ridge or Los Alamos say, "You have a great advantage over us; you have students."

In carrying out its role higher education by no means operates in a vacuum. It interacts strongly—more strongly than at any time in the past—with the federal government, it interacts with state and local governments, with industry, and this day and time with public interest groups. Although none of these interactions is problem-free, I believe the most serious problems today are in the area of university relations with the federal government, and I shall use my remaining time to comment on them.

The contract between society and academy actually originated many years ago in Europe, where society recognized the value of the modern university and gave its support to the learned professions because learning was intrinsically good. In our own nation the federal government was brought into the contract through legislative actions beginning with the Morrill Act. However, large scale federal involvement began following World War II with the National Science Foundation, the National Endowment for the Humanities, the National Institutes of Health, and other agencies.

From the end of the war until about ten years ago the contractual agreement evolved satisfactorily, but now there are signs that it is faltering. Brewster C. Denny, dean of the Graduate School of Public Affairs at the University of Washington described this situation well several months ago in an editorial in the journal *Science*.

... the old bargain is coming unstuck, largely because of the success of the American additions to the original European contract. Higher education, like government and health care, has become big business, and the general distrust of large institutions has reached the campus as well. The signs of deterioration of support and erosion of the contract are visible to all: the steady decline in support of the premier research and teaching institutions... the end of low or even free tuition in public institutions; severe budget problems in private colleges and universities; the declining use of merit pay for faculty; increasing government disincentives to philanthropic support of the arts and education; the attack on

peer review; politicization of boards of regents in public institutions; direct intrusion into university decisions by federal, state, and local government; and efforts to make university endowments and properties subject to direct political control.

I agree with Dean Denny that we need to negotiate a new contract, one that includes, as a national policy, recognition of our system of higher education as a vital national resource. Government support of universities should be considered an investment in the future of our civilization, rather than the purchase of research from a vendor. The largest reasonable degree of autonomy for institutions of higher education should be provided, because their contribution to society depends on it. They need stable support rather than "roller coaster" support under which they have been periodically called upon to help during the sputnik era or in solving the environmental crisis or the energy crisis.

To justify the public confidence which all of this will require, higher education must make a new commitment to accountability, to performance, and to a willingness to communicate to the public what it is doing and why. Anyone left in the ivory tower should descend.

I am glad to be able to report to you that in my judgement the negotiation of a new contract has begun—at least to the extent that a willingness to discuss our problems seriously has emerged among both government and higher education leaders. I cannot remember a time when more university presidents have met with more federal officials for this purpose than during the past year. I have participated along with other university presidents in many of these meetings with cabinet secretaries, undersecretaries, the White House Science Adviser, and heads of federal agencies; and a convincing commitment on both sides to resolve our problems is very apparent.

Moreover, concrete steps have been taken. Under the auspices of the Association of American Universities a National Commission on Research has been established to devise a comprehensive overhaul of the now cumbersome and bureaucratic procedures under which federal grants and contracts to universities are administered. On the federal side the President has begun fulfillment of his campaign pledge to diminish and disentangle the federal regulatory machine, and his recommended budget—if adopted—will end a ten-year slump in federal support of academic research. In a message to Congress on March 27, the President outlined a commendable federal science support policy. I hope that the Congress will respond positively. A beginning has been made, and our institutions of higher education must work strenuously and diligently for the success of this endeavor which is so important to our prosperity and welfare.

Industry - It's Needs and Expectations

Dr. Helmut R. R. Wakeham

Vice-President for Science and Technology
Philip Morris, Inc.

Ladies and Gentlemen:

This hour is late and I know that the span of attention for after dinner remarks is short. So I will be brief in expressing the view of one industrialist on the needs of industry from science education.

This position of "bringing up the rear" is very familiar to me because I had the fortune to be born with a name beginning with "W." This has not always been a disadvantage. Being in the rear I have sometimes had a better perspective of what is up front. So let me start with a few definitions.

If you ask the person on the street "Hey, what is science?" you will get answers like "Science is environmental pollution," "Science is television," "Science is computer, Venus probes, lasers." These are popular conceptions. But they are misleading. As we in the Virginia Academy of Sciences all know, science is systematized knowledge, attained through study or practice. Science is thought. The popular mind confuses material things with thought.

Scientific thought requires an act of faith on the part of the scientist. In fact, three acts are required. Act 1. The belief that we are in an orderly universe. Act 2. That by study human beings can understand that order. Act 3. The belief that it is good to have such understanding.

I believe there is order in the universe and I believe we can discern that order. Is it good to understand the order? Well, it's got to be good, otherwise I have to believe in the opposite that understanding is not good and say that ignorance is bliss. And I don't think any of you in this room is prepared to say that. But isn't it fantastic that in this day and age we are told there are some areas of knowing which should be forbidden fruits, that some knowing is evil.

Not long ago people were asked to vote yea or nea on DNA. We have witnessed a city council and mayor argue whether or not scientists should be allowed to do research on DNA recombination. Is it good or evil to know? What do you think when you hear DNA? Most people will think Frankenstein or Andromeda Strain. How many of them will tell you it's the beginning of a brighter and better way of life? Perhaps mutant children who lack some enzyme can literally be made whole. Perhaps we will have disease resistant plants and animals to feed the world.

Such is the intersection of knowing and applying that I foresee. Industry is at that intersection of knowing and applying. And this brings us to another key word of our evening: technology.

People commonly interchange the terms "technol-

ogy" and "science." Technology like science is also thought. It is the method or procedure (not the act) for applying basic scientific knowledge to a practical result. These results often present us with dichotomies such as reactors and bombs, automobiles and pollutants, television and behavior control. These are some of the terms of technology. They lead us into the question of fundamental moral judgments concerning how the knowledge of our universe is to be used. That is in the realm of ethics. Science tells us what is. Ethics tells us what ought to be.

The ethical fad of the day is absolute safety. Of course, there is no such thing as a risk-free society. Even a virtuous life has its risk, as illustrated by the Chinese proverb: "The couple who go to bed early to save candles end up with twins." Nevertheless, the Naderite interventionists, the Congress, and lately even the courts are reflecting citizenry expectations of safety. We have a host of regulatory agencies carrying out with religious zealotry the mandates of Congress for consumer protection. Nearly always the whipping boy is industry which is expected to produce only perfect, idiot proof products. This despite the findings that 75 percent of accidents and mishaps are caused by human factors. Recent examples are the Three Mile Island nuclear power plant mishap and the 727 crash in San Diego.

The cost of protection is enormous—not only the costs of safeguards and recalls, but also the social costs of operating the regulatory agencies. Ultimately the consumer pays in the prices of services or products the added charges of safety. Whether he wants or needs the new layer of protection, the man of common sense must pay to make things safe for the village idiot. Society experiences another loss of freedom which hurts more people than it helps. Most disadvantaged will be the poor who will find less on the market that they can afford.

The resolution of these problems can only be brought about by understanding. Ignorance leads to uncertainty, anxiety and fear. Understanding comes from knowledge. Chemophobia, fumophobia, defecophobia, nuclearphobia arise largely through lack of perspective of what is known and through extreme extrapolation from unknown to fear and on to hopeless panic. Very few protesters are really knowledgeable. Most are caught up in a mass hysteria fed by power hungry zealots. Even the media are guilty. Instead of bringing about understanding and perspective and rational assessment they favor sensationalism by shouting panic buzz words like "poisonous chemicals,"

"toxic fumes," and "radiation damage." Much less frequently do they give out factional information about probabilities, relative concentrations, and benefits. Many want to be heroes by letting us all know "the sky is falling."

Industry, producing goods and services under the free enterprise system, has brought about the highest standard of living in the world. People in developing countries yearn for better life and try to emulate our system. Our Virginia prosperity stems from at least three hundred major industrial organizations based on scientific and technological knowledge. They only exist because they are able to recover some financial return on the financial investment they have made in technical applications. Such applications only come about through the diligent and honest efforts of Virginians. And yet, many consider the return immoral because it is called "profit." They overlook the fact that everyone who survives—the teacher, the government worker, the factory manager, the farmer, and even the welfare recipient "profits" in some way or other from his effort.

Most industries these days depend in one way or another on the applications of science and technology. But more importantly they depend on people. Educated people. People who can learn to operate the complex technological systems introduced to increase worker productivity and to make possible greater rewards. People who can understand cause and effect, risk and benefit, chance and probability, profit and loss. People who can communicate effectively and efficiently.

As our society expands and develops in complexity, instead of finding more and more people with these qualities, we find fewer of them. Not that our high schools, colleges, and universities have fewer students. It is just that fewer of them seem to be qualified to become productive in industrial systems. Several aspects of this problem deserve elaboration.

In the first place, many potential employees lack basic skills in, for example, the three R's. Many graduates fail simple reading and writing requirements. The recent publication of a test for mathematical skills required of high school graduates was to many of us a depressing revelation of how schooling standards have changed. And why not? Who wants to learn multiplication tables when pocket computers are handy? But do mental skills improve with pocket calculations?

A second problem for industry is that proportionally fewer students are going into the engineering, mathematical, and physical sciences than before. This situation stems partly from the belief that the problems of the world are brought about by the applications of science and technology. There is now developing a very serious shortage of qualified scientists and engineers which will be with us for at least a decade. Furthermore, more graduates are attracted to secure governmental and institutional positions than to industry where disciplines and performance demands are more apt to be applied.

Both technical and liberal arts graduates usually require a long time to adjust to the business environment in industry. They are inexperienced in employing their skills for business purposes. They are often unfamiliar, and sometimes even opposed, to the free enterprise capitalistic system. They have little concepts of budgets, cost control, resource management, profit and loss, or how to use their time efficiently.

Let me illustrate with an example familiar to me. Philip Morris tobacco operations in 1967 employed 79 persons to make a unit of product. Through automation and the introduction of high-speed, electronically-controlled machinery and extensive use of computers this number is now 59, and by 1981 it will be down to 52. The resulting increases in productivity enable us to provide increased pay and benefits to our work force and to keep up with our growing business. The people operating and servicing these new machines require extensive training, not only in the specialized technical skills required, but also, in many instances, in basic verbal and mathematical skills because new hirings lack these skills. This is true now only for factory operators but also for supervisors. For this reason, Philip Morris has extensive training facilities and training personnel for all levels of employee. Our Richmond training budget alone is over 6 million dollars.

Industry needs courageous, intelligent, educated, and trained people who are dedicated to excellence and achievement; and who, at the same time, recognize the interactions in our complex society and the need for trade-offs to make things work. Knowledge and understanding are fundamental to progress. We depend to a great extent on our educational institutions to provide us people with these qualities.

Statewide Survey of Psychology Majors in Virginia: Class of 1978

Frederick B. Rowe

Department of Psychology
Randolph-Macon Woman's College
Lynchburg, Virginia 24503

During its May 1978 Business Meeting the Psychology Section of the Virginia Academy of Science approved a plan to conduct a survey of all Virginia college and university psychology graduates receiving a degree in 1978. The survey's plan was to invite all academic departments or divisions to send the 1978 graduates a copy of the follow-up survey questionnaire, developed by the Southern Regional Education Board, under cover of a letter from the department chairman or other faculty member likely to be best known to the graduates. A copy of the questionnaire is available on request to the author. This paper is a summary of the results of the survey.

Twenty private and thirteen public institutions listed by the state's Council of Higher Education as having degree programs in psychology were invited to participate. All but two institutions accepted. Ferrum College declined because it was erroneously listed and did not offer a psychology major. Liberty Baptist College declined because it had not been in operation long enough to develop adequate alumni address files. Each of the 31 institutions which agreed to participate was provided with sufficient questionnaire copies for a original mailing plus a (50% anticipated) second mailing to those not responding within a month's time of the November 1978 recommended mailing period. It was also recommended that responses received by the departments be sent to us by the end of January 1979 so that the data could be processed in large batches.

Of the 31 institutions which had agreed to participate 19 actually sent in completed questionnaires—7 of the 13 public institutions and 12 private institutions. Hence, this report is based on a 59% haphazard sample of the state's colleges and universities. The shortcomings of institutional participation is aggravated by the fact that the public institutions participating submitted completed questionnaires on 313 respondents, 33% of their 1978 graduates. The 97 completed questionnaires from private institutions amounted to 36% of their classes of 1978.

Table I shows the numbers of degrees awarded by institutions for 1976-77 and 1977-78 academic years. Inspection of table shows that the public institutions' psychology programs produce nearly $\frac{3}{4}$ of the bachelors' degree graduates, nine out of ten of the masters' degrees, and all of the doctorates. Both Hollins College and the University of Richmond have substantial numbers of bachelors' degree graduates and the only

master's degree programs offered by the private institutions. Among the public institutions the programs at Longwood, Norfolk State and Virginia State produce no more graduates than some of the private institutions. It may be of interest to note the recent decline in the number of bachelors' degrees awarded by both public and private institutions—down 12% from 1977 to 1978.

Table II shows the demographic characteristics of the questionnaire respondents. Females outnumbered males by approximately 2 to 1. Whites outnumbered blacks and other minorities by an overwhelming majority. Virginia residents constituted 83% of the public institutions' respondents but slightly less than half of the private institutions' respondents.

The substantive items in the questionnaire fell into four categories: (1) The graduates' stated purpose in pursuing their study of psychology; (2) their opinions as to how well their colleges or universities had helped them to achieve their purposes; (3) the graduates' employment; (4) the graduates' further education.

The respondents' purposes in completing their psychology programs can be summarized as follows: both the public and the private institutions' respondents ranked general intellectual and social development in first place; they ranked knowledge in psychology in second place. Preparation for employment and for admission to graduate school were ranked third and fourth, respectively. These rankings are of course biased by the fact that the overwhelming majority of the respondents were recent bachelor's degree graduates.

Table III shows what the respondents felt about how their educational programs has helped them attain their purposes. Examination of the table shows that these graduates were most favorable in their evaluations of the help provided in attaining their liberal arts purposes and least favorable in their evaluations of their programs' help in preparing them for employment. It appears that somewhat more favorable evaluations were given by respondents from the private institutions.

The current employment picture of the respondents is shown in Table IV. It will be noted that employment rates are nearly identical among the public and private institutions' graduates. Fewer than 10% were unemployed and seeking employment. Those neither employed nor seeking included those continuing their

Table I

Council of Higher Education Report

Psychology Majors' Degrees Awarded, 1976-77/77-78

<u>PUBLIC INSTITUTIONS</u>	Bachelor's	Master's	Doctor's
Christopher Newport*	35/41		
George Mason*	87/69	35/40	
James Madison*	79/80	15/17	
Longwood*	9/11		
Mary Washington	40/40		
Norfolk State	13/21	0/3	
Old Dominion	99/84	10/7	
Radford*	32/16	27/37	
University of Virginia*	175/150	7/11	7/9
Virginia Commonwealth*	85/88	30/23	12/20
V.P.I. and S.U.	93/71	12/14	4/3
Virginia State	30/18	3/1	
William and Mary	67/58	4/5	0/3
SUBTOTALS	844/747	143/158	23/35
<u>PRIVATE INSTITUTIONS</u>			
Averett*	6/8		
Bluefield*	13/8		
Bridgewater	9/6		
Eastern Mennonite*	15/10		
Emory and Henry*	10/10		
Hampden-Sydney	23/9		
Hampton Institute	27/16		
Hollins*	30/23	10/1	
Liberty Baptist	12/13	(no alumni records)	
Lynchburg*	12/6		
Mary Baldwin*	16/21		
Randolph-Macon*	22/29		
Randolph-Macon Woman's*	14/6		
Rcancke*	13/26		
Sweet Briar*	8/14		
University of Richmond	40/34	9/10	
Virginia Union	9/8		
Virginia Wesleyan	8/4		
Washington and Lee*	14/6		
SUBTOTALS	301/257	19/11	
TOTALS 1976-77/77-78	1145/1004	162/169	23/35

* Institutions which participated in the survey.

Table II
Demographic Characteristics of Respondents

	<u>PUBLIC INSTITUTIONS</u>	<u>PRIVATE INSTITUTIONS</u>
Number Completed	313	97
Males	35%	31%
Females	65%	69%
White	94%	95%
Black	5%	4%
Others	1%	1%
Bachelors	81%	99%
Masters	18%	1%
Doctorates	1%	0%
Va. Residents	83%	49%
Birthdate Range	1914-1957	1940-1957
Modal Age	22	22

Table III

Percent of respondents' ratings of degree of help provided by their educational programs in attaining purposes.

<u>Purpose</u>		<u>Very Well</u>	<u>Adequately</u>	<u>Moderately</u>	<u>Not at all</u>
1. Enhance gen'l intell/soc development.	Public	52%	40%	9%	0%
	Private	70%	26%	4%	0%
2. Gain knowledge in interest area.	Public	50%	42%	9%	0.3%
	Private	57%	35%	6%	1%
3. Prepare for employment.	Public	16%	31%	36%	17%
	Private	10%	45%	35%	10%
4. Prepare for prof. schl.	Public	23%	44%	27%	5%
	Private	35%	42%	18%	5%

Table IV

Current Employment of Respondents

	Public %	Private %
Full-Time 30+ hrs./wk.	63	63
Part-Time 15 hrs./wk. min.	10	9
Unemployed and seeking	9	8
Homemaker - no other employment	2	2
Not employed or seeking (may include current students)	16	17
Employed in Virginia	78	58
Employed in: Private enterprise	38	38
Educ. instn/system	21	30
Fed.-State-Loc. Govt.	32	19
Other	9	14
Relat. of employment to Psyc. study:		
Directly	37	29
Somewhat	33	46
Not at all	30	25
Learned of present job through:		
Already employed before grad	20	9
College placement office	4	10
Employment agency	8	6
Newspaper ad	16	14
Faculty contact/referral	6	9
Friend/relative	28	36
Other	19	17
Overall Salary Range (\$1,000's)	Less than 6 to 30	Less than 6 to 17
Median Range	8 to 10	8 to 10
Job satisfaction in terms of:	Highly/Moderately	Highly/Moderately
Challenge	80	81
Salary	71	71
Long-range plans	64	70
Is job step toward career goals?:		
Yes	71	73
No	29	27

Table V

Present educational programs of respondents

	Public %	Private %
Enrolled and seeking another degree	29	30
Enrolled, but not seeking degree	8	2
Degree being sought:		
Associate/Bachelors	9	0
Masters	57	76
Doctorate	30	24
Other degree, certificate	4	0

education. The graduates of the public institutions were more likely to be employed in Virginia. Private enterprise, including self-employment, accounts for the largest number of jobs held. A substantial majority viewed their employment as directly or somewhat related to their studies. Nearly 3 out of 4 felt that their jobs were a step toward meeting their long-range career plans.

Median salaries were in the \$8,000-\$10,000 range and a substantial majority were moderately to highly satisfied with their salaries, the jobs' challenge, and the way in which their employment fitted their long-range plans. It is of interest to note that the old, tried and true method of learning about a job through friends, relatives and teachers is still very important—more so for the private than the public institutions' graduates. College placement offices and employment agencies take a back seat to newspapers' advertisements in their learning about jobs.

Table V shows the present programs of the minority who were pursuing another degree during the same year as their previous graduation. There were 92 of the 313 public institutions' graduates (29%) and 29 of the 97 private institutions' graduates (30%) who were continuing their educations. Although these percentages are nearly identical the public institutions' graduates were more diverse in the kinds or levels of degrees sought. This is, presumably, a function of both their large number and originally greater diversity in their previous programs.

If the present study were repeated by the Psychology Section of the Virginia Academy of Science or by another section, the experience gained here would suggest that in order to achieve full participation of all departments the following steps might help:

1. After the Section has agreed to conduct the survey it should then establish the survey calendar and procedures at its annual business meeting and appoint a central office for the survey.
2. Once individual college or university department or division chairmen have agreed to par-

ticipate, the survey's central office should secure the alumni mailing lists and the covering letters from each institution.

3. At the scheduled dates the central survey office does all of the original and follow-up mailings and, where necessary, telephones non-respondents.

If the steps suggested were followed, it would, presumably, be necessary to either have financial support from the Academy or a cost-sharing arrangement among the participating institutions. While the Academy has no precedent for institutional research it is certainly capable of making proposals for grants to private or public foundations, and its official sanction and support might be expected to strengthen the chances of a proposal receiving approval and funding.

The questionnaire used in the present study was, as stated at the outset, developed by the Southern Regional Education Board (SREB) as part of its continuing project on comparison of outcome data. SREB can and will serve as a clearinghouse for follow-up surveys in the region and will prepare and distribute comparisons of outcome data.

It would seem obvious that outcome data from follow-up surveys are useful not only to individual educational institutions for their program planning and evaluation, but also that their value can be increased by relating findings to those of similar institutions, at the level of the separate sections of the Virginia Academy of Science, the Academy as a whole, and, with the help offered by SREB, throughout the Southern Region.

References

- Galambos, E. C. *Follow-up surveys of college graduates: Procedures and commoncore of questions*. Atlanta: Southern Regional Education Board, 1978.
- Staff Technical Report. *Degrees Conferred 1976-77*. Richmond: Council of Higher Education, 1978.
- Staff Technical Report. *Degrees Conferred 1977-78*. Richmond: Council of Higher Education, 1979.

Geometrical Optics of Planar Interfaces¹

E. F. Turner² and H. T. Williams

Washington and Lee University
Lexington, Virginia 24450

Abstract—Assuming two media of different indices of refraction are joined at a planar interface, a derivation of the relationship between object position and image position is given. The derivation is initially given using no calculus, and then a shorter procedure, using derivatives, is shown. The dispersive properties of such an interface are also derived.

Introduction

In the teaching of geometrical optics, traditionally one seems to go from the introduction of Snell's Law directly into the treatment of image formation by spherical interfaces, spherical lenses, for example. The exact geometry of such situations is often so complicated as to necessitate the introduction of mathematical approximations, such as the thin lens approximation. Corrections to this, as well as questions concerning off-axis image formation are normally delayed until a discussion of aberrations, and this is often treated only qualitatively.

A quite normal first application of Snell's Law would seem to be a study of image formation by a flat surface bounding two transparent media. The physical consequences of such imaging should be quite familiar to any student having experienced spoons in glasses of water, swimming pools, or bathtubs.

Herein is a mathematical description of the image-forming properties, as well as the dispersive effects, of a planar interface between two media of different indices of refraction. The derivation of the image position is initially presented using geometry and the notion of the limit, and the same calculation is then outlined using differential calculus. Subsequent calculations are shown using derivatives to shorten the work.

Section II of this paper shows the calculation of the image position for an object in one medium viewed from a second medium. Section III shows the connection of this problem to a time minimizing puzzle. Section IV is a calculation of the dispersive effects of a planar interface, and an example is given of spectrum formation by a flat water surface.

Calculation of Image Position

The formation of a virtual image by a planar interface between two media of different indices of refraction is most easily visualized by using a technique of tracing two rays, distinct, but near one another. Figure 1 shows the geometry associated with the two rays from an object P a perpendicular distance D below the media interface I . The medium above the interface has index of refraction n_1 , that below has index of refraction n_2 . The line I represents the intersection of two

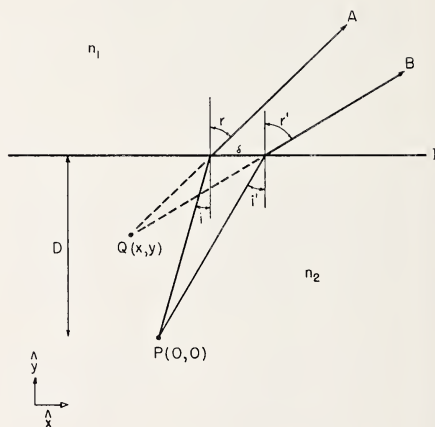


FIG. 1.—Ray diagram showing relationship of object, $P(O,O)$, and image formed by planar interface, $Q(x,y)$.

perpendicular planes—that of the interface and the plane of the two illustrated rays. Ray A (B) leaves the origin $P(O,O)$, intercepts the interface normal at an angle i (i'), and enters the second medium at an angle r (r') to the normal. From the point of view of an observer in medium 1, these two rays appear to have originated from a point $Q(x,y)$, above and to the right (if $n = n_2/n_1 > 1$) of $P(O,O)$. In the limit as the two rays approach one another, $Q(x,y)$ becomes the exact image position. It is the value of x and y as a function of r (or i) that is sought in this section.³

Snell's Law is obeyed by each ray, therefore

$$\sin r = n \sin i \quad (1)$$

and

$$\sin r' = n \sin i'. \quad (2)$$

Simple geometry leads to the additional equation

$$D \tan i + \delta = D \tan i', \quad (3)$$

where δ is the linear distance between the intersection of A with I , and the intersection of B with I . To find the intersection of the lines represented by rays A and B as they travel in the medium of index n_1 , the equation for these lines will be found. The line corresponding to A can be written

$$y = mx + b,$$

where m is the slope, and b the y intercept. From

geometry, $m = \cot r$. The value of b can be evaluated using the fact that at $y = D$, $x = D \tan i$. The equation for this line can thus be written

$$y = (x - D \tan i) \cot r + D. \quad (4)$$

Similarly, the line corresponding to ray B in medium 1 has the equation

$$y' = (x' - D \tan i') \cot r' + D,$$

or

$$y' = (x' - D \tan i - \delta) \cot r' + D, \quad (5)$$

using equation (3) to eliminate i' . These two lines (equation (4), (5)) intersect at $x = x'$, $y = y'$: combining these conditions with (4) and (5) gives

$$(x/D - \tan i - \delta/D) \cot r' = (x/D - \tan i) \cot r. \quad (6)$$

The x coordinate of the image position can be found by solving equation (6) for x , in the limit i' approaches i . This is expedited by expressing all angles in terms of the angle i . From equation (1)

$$\cot r = ((1 - n^2 \sin^2 i) / n^2 \sin^2 i)^{1/2},$$

from equation 2 and 3

$$\cot i' = (1 + (1 - n^2) \tan i + \delta/D)^{1/2} / n (\tan i + \delta/D).$$

Incorporating these into equation (6) gives

$$(x/D - \tan i - \delta/D) (1 + (1 - n^2) (\tan i + \delta/D)^{1/2} / (\tan i + \delta/D)) = (x/D - \tan i) (1 - n^2 \sin^2 i)^{1/2} / \sin i.$$

Solving for x , in the limit $\delta \rightarrow 0$,

$$x = D (n^2 - 1) \tan^3 i,$$

or expressed in terms of the angle in medium 1

$$x = D (n^2 - 1) (\sin^2 r / (n^2 - \sin^2 r))^{3/2}. \quad (7)$$

Equations (7) and (4) immediately yield the y coordinate of the image,

$$y = D (1 - ((1 - n^2 \sin^2 i) / (1 - \sin^2 i))^{3/2} / n), \quad (8)$$

This same result is attainable much more simply, if one is willing to sacrifice physical insight in favor of mathematical elegance. Considering only the single ray, A, its equation in medium 1 is given by equation 4,

$$y = (x - D \tan i) \cot r + D.$$

The fact that two nearby rays from $P(O,O)$ will appear to emanate from the same point $Q(x,y)$ implies that for this point

$$dy/di = dx/di = 0.$$

Differentiating equation (4) with respect to i , and incorporating these conditions,

$$0 = (x/D - \tan i) d(\cot r)/di - \cot r d(\tan i)/di.$$

Using equation (1) to evaluate $d(\cot r)/di$ leads to an equation for x identical to (7) and use of equation (4) gives a result for y identical to (8).

Figure 2 shows results of equations (7) and (8), image positions as a function of i for media of relative index of refraction $n = 1.5$. Note that when viewed from directly above, the image is displaced only along the y axis from the object,

$$x = 0, y = D (n - 1)/n;$$

when viewed along a line essentially parallel to the interface, the image is on the interface, and displayed laterally

$$y = D, x = D/(n^2 - 1)^{1/2}.$$

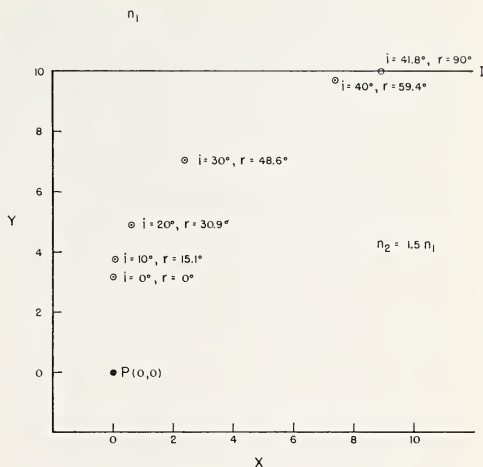


FIG. 2 — Image position x, y as a function of angle of incidence i and angle of refraction, r , for $n = 1.5$.

Drowning Swimmer Problem

The mathematics of the last section is applicable to a problem recently seen in the puzzle section of a scientific journal (*Technology Review* 78:64, June, 1976). A somewhat more general statement of the problem reads as follows (see figure 3).

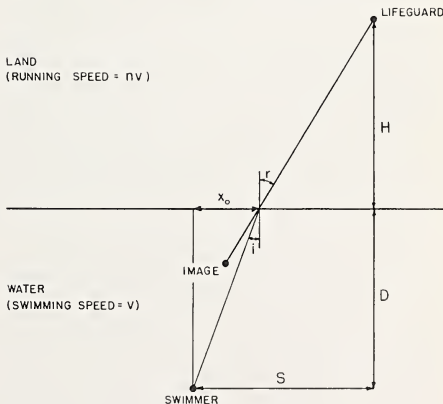


FIG. 3—Geometry of drowning swimmer problem.

A lifeguard on shore, a distance H from the straight shoreline of a body of water, spots a drowning swimmer a distance D from the shoreline, displaced a distance S parallel to the shoreline from him. If he can run a factor of n times faster than he can swim, at what point on the shore should he enter the water in order to minimize his time of travel to the swimmer?

The connection between this problem and the optics of section II is made through Fermat's principle. Fermat explains that light knows intuitively what the lifeguard must stop and think about: light, is going from one point to another, travels the path which will minimize the time of travel. The lifeguard should travel (backward) along the light ray which would reach his eye, having emanated from the swimmer, traveled to the shoreline in a medium of index of refraction n_2 and then to him through a medium of index of refraction n_1 (such that $n_2/n_1 = n$). In other words, the lifeguard should initially run towards the "image" of the drowning swimmer.

Consider a Cartesian coordinate system equivalent to that of figure 2, with the swimmer at the origin, and define the angles i , r as in figure 2. Simple consideration of the two right triangles in figure 3 yields

$$\tan i = x_0/D,$$

and

$$\tan r = (S - x_0)/H.$$

Using equation (7) to eliminate the angular dependence from these equations results in the expression

$$(S - x_0)/H = (n x_0/(D^2 - (1 - n^2) x_0^2))^{1/2},$$

which is transformable into a quartic equation for x_0 as a function of n , H , D , and S . Numerical techniques are necessary to give x_0 for specific values of these independent variables.

Dispersion

Due to the frequency dependence of the index of refraction of all transparent materials, light of different colors is refracted to different degrees at planar interfaces. "Rainbow" effects are often visible (and almost as often ignored) when white light, travelling in a transparent medium, enters the air through a planar interface.

Whereas the mathematics of this problem can also be handled with techniques similar to those of section II (using limits, but no calculus), the use of differentials greatly simplifies and shortens the effort, and they will be used here.

Assume a point source of white light to exist in a medium of refraction n_2 , to be observed from a medium with index of refraction n_1 . The two media are assumed separated by the planar interface I . The relative index of refraction $n = n_2/n_1$ is assumed to be a known, differentiable function of the light frequency. Figure 4 shows the geometry of this situation, and defines the parameters to be used in the following derivation. The two rays depicted represent light of slightly differing frequencies, both of which impinge on the observation point. The observer sees them as coming from different directions, and thus will see the

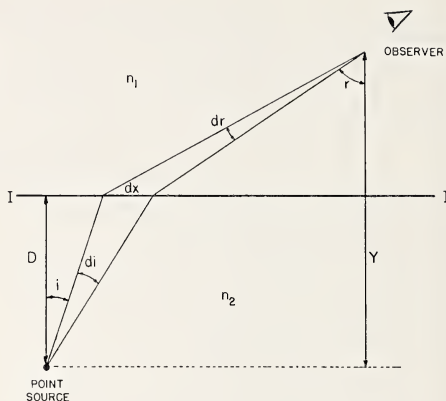


FIG. 4—Ray diagram for dispersion calculation.

image of the point source at different positions for different frequencies.

Refraction at the boundary for each ray is dictated by equation 1,

$$\sin r = n \sin i$$

Differentiation of this equation with respect to the relative index of refraction n yields,

$$\cos r \, dr/dn = \sin i + n \cos i \, di/dn$$

Use of the chain rule on the "i" derivative enables one to rewrite this expression as

$$\frac{dr}{dn} = \sin i / (\cos r - n \cos i \frac{di}{dr})$$

The term di/dn is most easily calculated by relating i to r via the differential line segment dx :

$$dx = d \sec^2 i \sin (di) = (D - Y) \sec^2 r \sin (dr)$$

It follows that, for infinitesimal di , dr ,

$$\frac{di}{dr} = (D - Y) \sec^2 r / (D \sec^2 i)$$

Inserting this into equation (9), and making use of equation (1), gives the following equation, describing the angular dispersion of light at the observer as a function of wavelength;

$$\frac{dr}{dn} = \frac{n \sin r \cos^2 r}{n^2 \cos^3 r + \frac{Y-D}{D} (n^2 - \sin^2 r)^{3/2}} \quad (10)$$

To illustrate the use of this formula, an example will be given of a situation in which the dispersive effects of a flat surface are easily observed. A 4' deep section of a swimming pool is observed by a person whose eyes are 6' from the surface of the water ($D = 4'$, $Y = 10'$). If a point source of white light were placed at the bottom of the pool, the observer would see a spectrum when observing the source at all angles except from directly above ($r = 0$). The angular size of this spectrum can be calculated upon picking a value for the angle of observation (60° , e.g.) and realistic values for the refractive

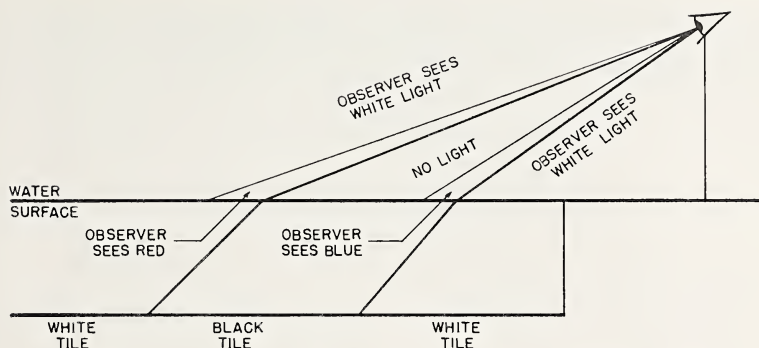


FIG. 5—Ray diagram showing results of observation of black region surrounded by white on pool bottom.

index of water for visible light ($n_{av} = 1.335$, $dn = .013$ for limits of visible spectrum). Using the given data in equation (10) yields $dr = 2.1 \times 10^{-3}$ radians $= .12^\circ$.

Unfortunately, most swimming pools do not have point light sources on the bottom. The effect is destroyed if the underwater light source (or reflective surface, like light colored pool floors) is extended. The spectra from the various points at the pool bottom recombine at the eye, giving the sensation of white light. The effect is easily seen, however, at the boundary between a light area of pool bottom (white tile, e.g.) and a dark area of pool bottom (black tile, e.g.). Since little or no light reaches the eye from the dark area, a section of the spectrum reflected from the nearby light colored area should be visible superimposed over the dark area, near the boundary, from the observer's point of view. The maximum effect is visible if the dark-light boundary is perpendicular to the plane of the observer and line of sight; no effect is visible if the boundary is in that plane. Figure 5 shows the angular regions of light entering the eye in the discussed example. Away from the dark region, the observer sees the white tiles as white. At the black

white boundary nearest the observer, the blue end of the spectrum will be seen just beyond the boundary. At the white-black boundary most distant from the observer, the red end of the spectrum will be seen just beyond the boundary. With the data given in the paragraph above, the two colored regions should have an angular size of about $.1^\circ$, about the angular size of a 1" section of pool floor seen by the observer. This is easily observed.

Footnotes

¹EDITOR'S NOTE: As a service to teaching members of the Academy, the VJS will occasionally publish papers which are primarily pedagogical rather than being research reports. Reviewers have recommended the publication of this paper in that context.

²Deceased.

³The image position can be found approximately by simply constructing the ray diagram of Figure 1, enforcing Snell's law for i , r and i' , and locating the intersection point Q of the emerging rays. This technique is used to construct image positions in F. a. Jenkins and H. E. White, *Fundamentals of Optics* (McGraw Hill, New York), p. 37.

Response of Aggressive versus Non-Aggressive Isolates of *Ceratocystis ulmi* to Benzimidazole Carbamate Fungitoxicants

Delano B. Janutolo and R. Jay Stipes

Virginia Polytechnic Institute and State University
Department of Plant Pathology and Physiology
Blacksburg, Virginia 24061

Abstract—Bioassay procedures for the *in vitro* response of aggressive and non-aggressive strains of *Ceratocystis ulmi* to benzimidazole fungitoxicants were evaluated. The zone of inhibition (ZOI) was larger at 5 ml, sharpest at 20 ml, but best overall at 10 ml agar/plate. Percentage of agar and type of Petri plate made no difference in ZOI. A pre-incubation period of 48 h at 4 C produced the best ZOI. Aggressive isolates were more tolerant to the fungitoxicants than the non-aggressive ones.

Introduction

It is important to know when examining the effects of a fungitoxicant on a fungus whether different cultural or geographical isolates of the fungal pathogen respond in different ways to the fungitoxicant. In 1971, a major epidemic of Dutch elm disease developed in southern Britain (Gibbs *et al.*, 1972). In searching for an explanation for the new epidemic, Brasier and Gibbs (1973) discovered that the form of *Ceratocystis ulmi* (Buism.) C. Moreau associated with the epidemic was more aggressive than isolates obtained elsewhere in Great Britain. When *C. ulmi* isolates from all over the world were examined, two culturally distinguishable groups emerged. Gibbs and Brasier designated these groups as aggressive or non-aggressive strains. Both forms were found readily in North America, while only the non-aggressive strain was generally found in Europe (Gibbs and Brasier, 1973; Schreiber and Townsend, 1976b).

Colony characteristics form the basis for distinguishing the aggressive from the non-aggressive form. In general, the aggressive isolates are fast growing with aerial mycelium, giving the colony a fluffy or cottony appearance. The non-aggressive isolates, on the other hand, are slow growing with a waxy or yeast-like appearance (Brasier and Gibbs, 1975). The term, non-aggressive, however, should not be confused with the term apathogenic. The non-aggressive isolates are pathogenic, but disease development within infected trees is slower than those trees infected with an aggressive isolate (Brasier and Gibbs, 1976).

The objective of the present study was to examine, by the bioassay disk technique (BDT), any differences in effects of benzimidazole fungitoxicants upon aggressive and non-aggressive strains of *C. ulmi* obtained from different areas of the world. To accomplish this objective, it was first necessary to investigate the different parameters governing the disk bioassay technique and to determine a model system for use in fungicide testing.

Materials and Methods

Parameters of the Disk Bioassay Technique (DBT). The DBT consisted of placing a 13-mm bioassay disk containing 100 μ l of a 100 μ g/ml solution of methyl-2-benzimidazole carbamate phosphate (MBC • H₃PO₄) on a glucose-yeast extract agar (GYEA) plate, surface-seeded with spores of *C. ulmi*. The plate was first incubated at 4 C for 24 h to allow diffusion of the toxicant, then at 25 C for about 2 wks to allow growth of *C. ulmi*. The Zones of Inhibition (ZOI) were then recorded. In Test I, GYEA plates contained varying depths of agar with 5, 10, 15, or 20 ml/plate with all other variables held constant. In Test II, plates were incubated at 4 C for various time periods: 0, 24, 48, 72 and 96 h. In Test III, different concentrations of agar (1.0, 1.5, 2.0%) in the GYEA were used. Test IV consisted of examining the effect of glass versus plastic Petri dishes on DBT. Only 9 cm-diameter plates were used in these and the following experiments. For each test there were 12 replications/treatment, and each test was repeated at least twice. Results were analyzed by Duncan's new multiple range test (Walpole and Myers, 1972).

Bioassay of Aggressive versus Non-Aggressive Strains of *C. ulmi* One hundred μ l of a 10 μ g/ml solution of either methyl-2-benzimidazole carbamate (MBC), MBC • HCl or MBC • H₃PO₄ were applied to a 13 mm cellulose penicillin bioassay disk. The disk was placed on GYEA surface-seeded with conidia from one of six *C. ulmi* isolates. The plate was stored at 4 C for 24 h and incubated at 25 C for 48 h. A ZOI was recorded. The six *C. ulmi* isolates used included both an aggressive and a non-aggressive isolate from the Netherlands, the United Kingdom and the United States (Iowa). The experiment was repeated twice with 10 replications/isolate/chemical and analyzed with Duncan's New multiple range test at the 5% level (Walpole and Myers, 1972).

Results and Discussion

Parameters of the DBT. Increase in size of the ZOI was inversely proportional to an increase in the quantity of agar per plate. While the ZOI was significantly larger at an agar volume of 5 ml, the ZOI was sharpest at 20 ml of agar/plate. Ten ml of agar/plate yielded the best overall ZOI; it was large, yet sharp and easy to read (Table I).

Table I. Effect of depth of agar on the size of the zone of inhibition (ZOI) in the disk bioassay technique.

Depth of Agar (ml)	Mean of ZOI (cm)	Trenchancy of ZOI
5	6.45 a*	hazy
10	6.17 b	sharp
15	5.73 c	sharp
20	5.46 d	very sharp

* Within column means followed by the same letter are not significantly different at the 5% level of probability as determined by Duncan's new multiple range test.

Table II. Effect of incubation period at 4 C on the size of the zone of inhibition (ZOI) in the disk bioassay technique.

Incubation Period (h)	Mean of ZOI (cm)	Trenchancy of ZOI
0	4.56 a*	hazy
24	5.32 b	sharp
48	6.19 c	sharp
72	6.67 d	hazy
96	7.10 e	hazy

* Within column means followed by the same letter are not significantly different at the 5% level of probability as determined by Duncan's new multiple range test.

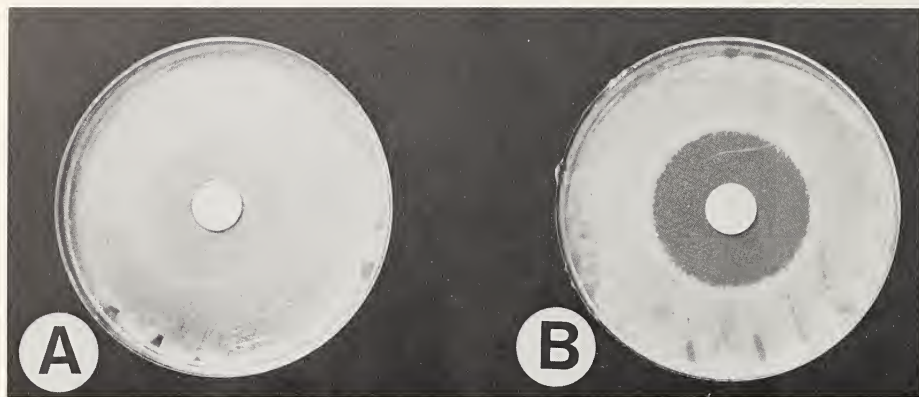


FIG. 1—Zones of inhibition of aggressive (A) versus nonaggressive (B) isolates of *Ceratocystis ulmi* after incubation at 25 C for 4 wks.

Increase in the size of the ZOI was directly proportional to an increase in the incubation period at 4 C. An incubation period of 48 h at 4 C produced the largest ZOI that was sharp and easy to read (Table II).

Percentage of agar and type of Petri dish had no significant effect on the ZOI.

After examining the parameters of the BDT, the necessity of holding all variables constant when conducting comparative studies was clear, especially the quantity of agar/plate and the incubation period at 4 C. An incubation period at 4 C of 48 h, 10 ml of agar/plate and a medium containing 2.0% agar dispensed into plastic Petri dishes were chosen for the model system.

Bioassay of Aggressive and Non-Aggressive Isolates of *C. ulmi*. For all fungitoxicants, the ZOI of the Dutch non-aggressive isolate was significantly larger than that of the Dutch aggressive isolate. The zones of inhibition of the English isolates were not significantly different, and those of the Iowa isolates were not consistent among replications. The ZOI of the non-aggressive isolates was very sharply demarked, and there was no fungal development in the ZOI after an incubation period of 4 wks. The aggressive isolates, however, exhibited a hazy ZOI which was completely overgrown by the fungus after incubation of 2 wks at 25 C (Figure 1).

Because of the hazy appearance and eventual overgrowth of the ZOI by the fungus with aggressive isolates, it was concluded that the aggressive isolates exhibit a more tolerant or less sensitive reaction to the

fungitoxicants than the non-aggressive isolates. This phenomenon coupled with natural occurrence of MBC-tolerant *C. ulmi* isolates reported by Schreiber and Townsend (1976a), might explain in part the variation in efficacy of treatment of Dutch elm disease with benzimidazole compounds.

Literature Cited

- Brasier, C. M. and Gibbs, J. N. (1973): Origin of the Dutch Elm Disease Epidemic in Britain. *Nature* 242, 607-609.
- Brasier, C. M. and Gibbs, J. N. (1975): Variation in *Ceratocystis ulmi*: Significance of the Aggressive and Non-Aggressive Strains. In *Dutch Elm Disease* (D. A. Burdekin, and H. M. Heybroek, eds.), pp. 53-75. Proc. IUFRD Conf., U. S. Dept. Agric. For. Serv. 94 p., Upper Darby, PA.
- Brasier, C. M. and Gibbs, J. N. (1976): Inheritance of Pathogenicity and Cultural Characters in *Ceratocystis ulmi*: Hybridization of Aggressive and Non-Aggressive Strains. *Ann. Appl. Biol.* 83, 31-37.
- Gibbs, J. N. and Brasier, C. M. (1973): Correlation Between Cultural Characters and Pathogenicity in *Ceratocystis ulmi* from Britain, E. Europe and America. *Nature* 241, 381-383.
- Gibbs, J. N., Heybroek, H. M., and Holmes, F. W. (1972): Aggressive Strain of *Ceratocystis ulmi* in Britain. *Nature* 236, 121-122.
- Schreiber, L. R. and Townsend, A. M. (1976a): Naturally Occurring Tolerance in Isolates of *Ceratocystis ulmi* to Methyl-2-benzimidazole Carbamate Hydrochloride. *Phytopathology* 66, 225-227.
- Schreiber, L. R. and Townsend, A. M. (1976b): Variability in Aggressiveness, Recovery, and Cultural Characteristics of Isolates of *Ceratocystis ulmi*. *Phytopathology* 66, 239-244.
- Walpole, R. E. and Myers, R. H. (1972): *Probability and Statistics for Engineers and Scientists*. 506 p., MacMillan Co., NY.

Obituaries

WILLIAM MILLER HINTON

William M. Hinton, Professor Emeritus of Psychology, died in Lexington, Virginia, on January 1, 1979.

Born in Kentucky, Dr. Hinton's affiliation with Washington and Lee University began when he enrolled as a freshman in the fall of 1925 and continued until the first day of this new year. He received a bachelor's and then a master's degree from Washington and Lee and subsequently earned his doctorate in psychology from Ohio State University. Except for a year of residence in graduate school and for four years of military service during World War II, in which he

attained the rank of lieutenant colonel, Dr. Hinton remained at Washington and Lee during his entire academic career—a period of more than half a century. The University of Virginia was fortunate to have him teach as Visiting Professor of Psychology for 25 successive summers beginning in 1947. His contributions to professional organizations were recognized by his colleagues at other institutions through his election to positions of leadership in several learned societies, including the presidency of the Virginia Psychological Association in 1956, the Virginia Academy of Science in 1959, and the Southern Society for Philosophy and Psychology in 1962.

ESMARCH SENN GILREATH

Esmarch Senn Gilreath, head of the chemistry department at Washington and Lee University for 15 years until 1970 and a member of the W&L faculty for 29 years, died at his home March 3, 1979 at age 74.

Prof. Gilreath was born September 21, 1904, in North Wilkesboro, N.C., the son of the late Dr. and Mrs. Frank Hatchett Gilreath. He earned his A.B., M.A. and Ph.D. degrees in chemistry from the University of North Carolina, where he also taught while working on his doctorate. He spent a year as a research chemist for American Enka Corp. Before joining the W&L chemistry faculty in 1946. He became department head in 1955 and returned to full-time teaching in 1970. He retired in 1975.

"He was an effective teacher—particularly in designing and developing experiments for student use," William J. Watt, dean of the College at W&L and a fellow chemistry professor, had remarked upon Dr. Gilreath's retirement in 1975.

The son of a physician, he was particularly inter-

ested in Washington and Lee's pre-medical curriculum, and during most of his teaching career he was the university's advisor to pre-med students.

He was the author of a number of college-level chemistry textbooks, including "Elementary Qualitative Analysis" (1969), "Experimental Procedures in Elementary Qualitative Analysis" (1968), "Fundamental Concepts of Inorganic Chemistry" (1958) and "Qualitative Analysis" (1954, translated into Spanish and published in that language in 1960).

His scholarship and writing were so highly regarded that one publisher wrote to him in 1968: "We could seek further critical opinions at this point, but prefer to go right ahead with copy editing without further delay. We are confident of the quality of the manuscript".

During the summers, Dr. Gilreath was frequently a visiting professor at other colleges, including the Universities of North Carolina, British Columbia, and Oregon. He spent much of his free time gardening and was a science-fiction enthusiast.

Virginia Academy of Science

Membership List

1979

LIFE MEMBERS

Mr. Rodney C. Berry
5907 Brookfield Rd.
Richmond, Va. 23227

Dr. Lewis H. Boshier, Jr.
M.C.V. Station
Richmond, Va. 23219
Dr. D. Rae Carpenter, Jr.
Physics Department
Virginia Military Institute
Lexington, Va. 24450

Arthur P. Coleman, Jr.
1053 N. Chambliss St.
Alexandria, Va. 22312

Dr. J. C. Forbes
421 Boone Road
Eden, N.C. 27288

Mr. E. S. Harlow
4545 Monument Avenue
Richmond, Va. 23230

Dr. Boyd Harshbarger
213 Country Club Dr., S.E.
Blacksburg, Va. 24060

Dr. Howard W. Hembree
Surfsedge, Apt. 702
4001 Gulfshore Blvd. N.
Naples, Fl. 33940

Dr. George W. Jeffers
500 First Ave.
Farmville, Va. 23901

Dr. M. A. Jimenez
1604 Trebov Ave.
Richmond, Va. 23226

Dr. Mary E. Kapp
208 N. Vine Street
Richmond, Va. 23220

Dr. John E. Manahan
Scottsville, Va. 24590

Dr. A. B. Massey
411 Clay St., S.W.
Blacksburg, Va. 24060

Mr. Beverly Orndorff
Science Editor
Richmond Times Dispatch
333 E. Grace St.
Richmond, Va. 23219

Powers & Anderson
4821 Bethlehem Road
Richmond, Va. 23230

Scott and Stringfellow
Mutual Building
Richmond, Va. 23219

Dr. Robert F. Smart
Dean's Office
7003 University Drive
Richmond, Va. 23229

Edmund Strudwick, Jr.
1536 Park Ave.
Richmond, Va. 23220

Dr. J. Ives Townsend
Box 33
M.C.V. Station
Richmond, Va. 23298

BUSINESS MEMBERS

Allied Chemical Corporation
Mr. I. C. Twilley
P.O. Box 31
Petersburg, Va. 23803

American Chemical Society
Virginia Section
P.O. Box 899
Hopewell, Va. 23860

American Filtrona Corp.
P.O. Box 34668
Richmond, Va. 23234

The American Tobacco Co.
Research & Development Dept.
P.O. Box 899
Hopewell, Va. 23860

Bunton Instrument Co. Inc.
615 Stonestreet Ave.
Rockville, Md. 20850

C & P Telephone Company
Attn: H. R. Stallard
Gen. Eng. Mgr.
703 E. Grace Street
Richmond, Va. 23219

Carolina Biological Supply
Attention: Library
Burlington, N.C. 27215

Central National Bank
Attn: Lewis N. Miller, Jr.
P.O. Box 27602
Richmond, Va. 23261

Ethyl Corporation
Attn: Mr. Charles H. Zeannah
Dir. Corp. Publ. Rel. Dept.
330 S. 4th Street
Richmond, Va. 23217

General Electric Co.
Attn: John C. Brennan
District Manager
P.O. Box 6974
Richmond, Va. 23230

Merck & Co. Inc.
Attn: Mr. A. H. Joecks
Merck Chemical Mfg. Division
Elkton, Va. 22827

Philip Morris U.S.A.
Attn: Dr. R. B. Siligman
P.O. Box 26583
Richmond, Va. 23261

Southern Bank & Trust Co.
Attn: Mr. H. H. Harris, Jr.
2nd & Grace Streets
Richmond, Va. 23215

Southern States Coop., Inc.
Mr. Charles F. Bahen
Box 26234
Richmond, Va. 23260

United Virginia Bankshares, Inc.
Attn: Library
P.O. Box 6-E
Richmond, Va. 23219

Universal Leaf Tobacco Co.
Mr. B. S. Holt, Jr.
Asst. Vice President
P.O. Box 25099
Richmond, Va. 23260

Virginia Chemicals Inc.
Attn: Logan C. Bostian
3340 West Norfolk Road
Portsmouth, Va. 23703

Virginia Electric & Power Co.
7th & Franklin Sts.
Richmond, Va. 23219

SUSTAINING MEMBERS

Dr. Lynn D. Abbott, Jr.
607 Horsepen Road
Richmond, Va. 23299

Alderman Library
Exchange Divisions
University of Virginia
Charlottesville, Va. 22903

Dr. Lee S. Anthony
Physics Department
1229 Forest Lawn Drive
Salem, Va. 24153

Bridgewater College
Library
Bridgewater, Va. 22812

Mr. B. M. Bruner
105 North Wilton Road
Richmond, Va. 23226

Dr. Arthur W. Burke, Jr.
2114 Shady Grove Rd.
Mechanicsville, Va. 23111

Christopher Newport College
Box 6070
Newport News, Va. 23606

Dr. James W. Cole, Jr.
900 Rosser Lane
Charlottesville, Va. 22903

College of William & Mary
Attn: Dr. George R. Healy
Williamsburg, Va. 23185

Dr. Robert J. Faulconer
Pathology Department
De Paul Hospital
Norfolk, Va. 23505

Froehling & Robertson, Inc.
Attn: J. M. George
P.O. Box 27524
Richmond, Va. 23261

Mr. Herbert O. Funsten
116 Mill Neck Road
Williamsburg, Va. 23185

Prof. Ray A. Gaskins
P.O. Box 311
Hampden-Sydney, Va. 23943

George Mason University
Fenwick Library
400 University Dr.
Fairfax, Va. 22030

Mr. Edward T. Harrison, Jr.
438 Quackenbos Street, N.W.
Washington, D.C. 20011

Mr. William P. Harrison, Jr.
P.O. Box 364
Blacksburg, Va. 24060

Dr. Horton H. Hobbs, Jr.
Room 301
U.S. National Museum
Washington, D.C. 20025

James Madison University
Attn: Accounting Department
Harrisonburg, Va. 22807

Dr. W. T. Joyner
Physics Department
Hampden-Sydney College
Hampden-Sydney, Va. 23943

Mr. Clyde Y. Kramer
Statistics Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Longwood College
Dabney Lancaster Library
Farmville, Va. 23901

Lynchburg College
The Library
Lynchburg, Va. 24501

Mary Washington College
E. Lee Trinkle Library
Box 1038, College Station
Fredericksburg, Va. 22401

Mathematics & Science Center
2401 Hartman Street
Richmond, Va. 23223

Dr. Susan J. Mellette
Box 207
Medical College of Virginia
Richmond, Va. 23219

Mr. James W. Midyette, Jr.
604 Maple St.
Ashland, Va. 23005

Old Dominion University
Library
P.O. Box 6173
Norfolk, Va. 23508

Dr. W. Allan Powell
Box 86
University of Richmond
Richmond, Va. 23173

Mr. Boyd E. Quate
P.O. Box 7065
Holland Station
Suffolk, Va. 23437

Randolph-Macon College
Ashland, Va. 23005

Randolph-Macon Women's College
Dr. R. A. Spivey
2500 Rivermont Avenue
Lynchburg, Va. 24503

Roanoke College
Dr. Norman D. Fintel
President
Salem, Va. 24153

Dr. Stephen V. Romanoff
1 Upham Drive
Richmond, Va. 23227

Dr. Russell J. Rowlett, Jr.
Chemical Abstracts Service
Ohio State University
Columbus, Oh. 43210

Mr. Edgar V. Russell, Jr.
707 York Drive
Blacksburg, Va. 24060

Science Museum Assoc. of
Roanoke Valley
2323 Overlook Road, NE
Roanoke, Va. 24012

Science Museum of Virginia
2500 West Broad Street
Richmond, Va. 23220

Milton W. Skolaut, Jr.
Box 2123
Newport News, Va. 23602

Society of the Sigma Xi
Virginia Tech. Chapter
S. A. Tolin Price Hall
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. John W. Stewart
Physics Department
University Station
Charlottesville, Va. 22903

Mr. Jackson J. Taylor
2431 Swathmore Road
Richmond, Va. 23235

Dr. Wilton R. Tenney
1507 Cutshaw Place
Richmond, Va. 23226

Dr. Vidgor L. Teplitz
Physics Department
V.P.I. & S.U.
Blacksburg, Va. 24060

Texas A & M University
Library - Serials Record
College Station, Tx. 77843

University of Richmond
Attn: Dr. Melvin Vulgamore
Richmond, Va. 23173

University of Virginia
Office of the University Comptroller
P.O. Box 3727
University Station
Charlottesville, Va. 22903

Ira Amon Updike
6075 N.W. 16th Ct.
Margate, Fl. 33063

V.P.I. & S.U.

Attn: Dr. Stuart K. Cassell
Blacksburg, Va. 24061

Virginia Commonwealth University

Attn: James Branch Cabell Library
901 Park Ave.
Richmond, Va. 23284

Virginia Blue Ridge Section

S. J. Wetmore, Jr., Chemistry Department
Virginia Military Institute
Lexington, Va. 24450

Virginia Military Institute
Lexington, Va. 24451

Virginia State College

Dr. Thomas M. Law, President
Box T
Petersburg, Va. 23203

Virginia Union University

Attn: Dr. M. E. Toney
1500 N. Lombardy St.
Richmond, Va. 23220

Washington & Lee University

Cyrus Hall, University Library
Lexington, Va. 24450

Dr. William J. Watt

Chemistry Department
Washington & Lee University
Lexington, Va. 24450

CONTRIBUTING MEMBERS

Dr. J. Frances Allen

7507 23rd Ave.
Hyattsville, Md. 20783

Dr. John C. Bartone

4111 Gallows Road
Annandale, Va. 22003

Dr. Michael L. Bass

Biology Department
Mary Washington College
Fredericksburg, Va. 22402

Dr. C. Cooper Bell, Jr.

Chief of Staff
Veterans Administration Center
Hampton, Va. 23667

Dr. Wilson R. Bell

1301 Hillcrest Dr.
Blacksburg, Va. 24060

Mr. Joseph F. Borzelleca

Pharmacology Dept.
M.C.V. Station
Richmond, Va. 23298

Dr. Edward R. Bowman

Pharmacology Department
M.C.V. Station
Richmond, Va. 23219

Dr. William P. Boyer

4710 Rolfe Rd.
Richmond, Va. 23221

Dr. Russell C. Brachman

139 Pendelton Rd.
Danville, Va. 24541

Dr. Ted Bradley

Biology Department
George Mason University
Fairfax, Va. 22030

Miss M. Sharon Brady

Rt. 2, Box 61
Mt. Jackson, Va. 22842

Mr. C. E. Brogden

11 Greenway Lane
Richmond, Va. 23226

Mr. James S. Brown, Jr.

P.O. Box 1871
Roanoke, Va. 24008

Prof. G. Preston Burns

600 Virginia Ave.
Fredericksburg, Va. 22401

Willard W. Burton

6808 Greenvale Drive
Richmond, Va. 23225

Dr. Addison D. Campbell

520 Julian Road
Richmond, Va. 23229

Mrs. Dawn S. Campbell

8520 Julian Road
Richmond, Va. 23229

Dr. E. G. Cogbill

The American Tobacco Co.
P.O. Box 899
Hopewell, Va. 23860

Dr. Pascal W. Cooper

301 Ohio Avenue
Harrisonburg, Va. 22801

Dr. C. E. Copeland

257 E. 39th Street
Norfolk, Va. 25304

Dr. H. L. Cover

1607 Franklin St.
Fredericksburg, Va. 22401

Ms. Mary Lee Cox

3654 Radford St.
Norfolk, Va. 23513

Dr. Eugene R. Crittenden

1762 East Boulevard
Petersburg, Va. 23805

Dr. Sue S. Cross

Pathology Department
Box 662
Medical College of Virginia
Richmond, Va. 23298

Dr. Colgate W. Darden, Jr.

1536 One Commercial Pl.
Norfolk, Va. 23510

William E. Davies

125 W. Greenway Blvd.
Falls Church, Va. 22046

Dr. J. E. Davis, Jr.

Biology Department
James Madison University
Harrisonburg, Va. 22807

Dr. Loyal H. Davis

7108 Hillsdale Drive
Richmond, Va. 23229

Mr. Ralph L. Disney

Ind. Engr. & Oper. Res. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Fred Ellerbusch

1820 Dolly Madison Blvd.
McLean, Va. 22101

Dr. R. W. Engel

USAID/Philippines
USAID/State Department
Washington, D.C. 20523

Dr. Bruce V. English

P.O. Box 267
Ashland, Va. 23005

Dr. W. J. Fabrycky

Dean, Research Division
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Lyman M. Fisher

9202 Waterloo Court
Richmond, Va. 23229

Dr. Franklin F. Flint

Box 309
Randolph-Macon Women's College
Lynchburg, Va. 24505

Ms. Ruth Freidman

204 Kent Avenue
Fredericksburg, Va. 22401

Mr. Philip C. Freund
P.O. Box 3654
Martinsville, Va. 24112

Mr. Robert F. Gillespie, Jr.
P.O. Box 41
Woodberry Forest, Va. 22989

Mr. Randolph N. Gladding
4600 Cutshaw Ave.
Richmond, Va. 23230

Dr. J. Brown Goehring
Chemistry Department
Washington & Lee University
Lexington, Va. 24450

Mr. Henry W. Gould
Mathematics Department
West Virginia University
Morgantown, W. Va. 26505

Dr. William T. Ham, Jr.
Box 877
M.C.V. Station
Richmond, Va. 23298

Dr. Edith L. Hardie
P.O. Box 117
Medical College of Virginia
Richmond, Va. 23298

Col. S. M. Heflin
508 Highland Road
Lexington, Va. 24450

Mrs. Roscoe D. Hughes
Powhickery Farm
6400 Chamberlayne Road
Mechanicsville, Va. 23111

Andrew L. Ingles
1006 3rd St., West
Radford, Va. 24141

Mrs. E. W. Jamison
20600 Southlawn Ave.
Petersburg, Va. 23803

Dr. Rose Mary Johnson
Box 1182
Fredericksburg, Va. 22401

Dr. Harry G. M. Jopson
Bridgewater College
Bridgewater, Va. 22812

Dr. M. A. Kise
112 Monitor Road
Portsmouth, Va. 23707

Dr. Paul H. Knappenberger, Jr.
2500 W. Broad St.
Richmond, Va. 23220

Dr. Preston H. Leake
5400 Tomahawk Dr.
Midlothian, Va. 23113

Dr. T. E. Leinhardt
622 Woodland Dr., N.W.
Blacksburg, Va. 24060

Mr. Gerardo J. Lombardi
165 Kohl St.
Broomfield, Co. 80020

Dr. Eugene Lundquist
P.O. Box 477
Hampton, Va. 23369

Dr. Carl D. Lunsford
A. H. Robins Co., Inc.
1407 Cummings Dr.
Richmond, Va. 23220

Dr. Maurice P. Lynch
Va. Inst. Marine Science
Gloucester Point, Va. 23062

Mr. Robert L. Lynch
4701 Stuart Ave.
Richmond, Va. 23226

Dr. M. A. Manzelli
3412 Lochinvar Drive
Bon Air, Va. 23235

Dr. Thomas J. Marlowe
Animal Science Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Richard Alan Mayes
Biology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. George A. McAlpine
School of Engineering
University of Virginia
Charlottesville, Va. 22903

Dr. Frank C. McCue, III
University of Virginia Hospital
Charlottesville, Va. 22908

Mrs. Leroy Moran
2552 Sweetbriar Ave. SW
Roanoke, Va. 24015

Dr. S. S. Obenshain
2010 Price Fork Rd.
Blacksburg, Va. 24060

Mr. Thomas C. Olsen
816 Pine Crest Ave.
Bedford, Va. 24523

Dr. Paul J. Osborne
Lynchburg College
Lynchburg, Va. 24504

Dr. Fletcher B. Owen, Jr.
1407 Cummings Dr.
Richmond, Va. 23220

Mr. John L. Perry
1048 Fairlawn Avenue
Virginia Beach, Va. 23455

Mr. Daniel J. Peters
P.O. Box 547
Yorktown, Va. 23690

Mr. Howard L. Price
275 Queens Dr.
Williamsburg, Va. 23185

Richard S. Ragland
304 Apperson Dr.
Blacksburg, Va. 24060

Mrs. Vera B. Remsburg
Box 789
Abingdon, Va. 24210

Mr. Maurice B. Rowe
Sec. of Commerce & Resources
P.O. Box 1475
Richmond, Va. 23212

Dr. J. G. Dos Santos
2 Glenbrook Cr. West
Richmond, Va. 23229

Mr. James L. Schwing
Math. & Comp. Sciences Department
Old Dominion University
Norfolk, Va. 23508

Dr. D. Scott Sears
8131 Sawmill Rd.
Richmond, Va. 23229

Dr. Paul B. Siegel
Poultry Science Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Billy W. Sloope
8718 Avalon Ave.
Richmond, Va. 23226

Dr. James H. Starling
207 Paxton Rd.
Lexington, Va. 24450

Dr. Averett S. Tombes
Biology Department
George Mason University
Fairfax, Va. 22030

Dr. Carl Trindle
Chemistry Department
University of Virginia
Charlottesville, Va. 22901

Dr. Dale V. Ulrich
Bridgewater College
Bridgewater, Va. 22812

Dr. L. W. Webb, Jr.
5234 Edgewater Dr.
Norfolk, Va. 23508

Dr. Warwick R. West, Jr.
Box 248, University of Richmond
Richmond, Va. 23173

Dr. Stanley B. Williams
Psychology Department
College of William & Mary
Williamsburg, Va. 23185

Dr. Doris Wilsdorf
Physics Department
University of Virginia
Charlottesville, Va. 22903

Mr. John W. Wilson
4 Mears Circle
Newport News, Va. 23602

Dr. John H. Wise
Chemistry Department
Washington & Lee University
Lexington, Va. 24450

Bernard R. Woodson, Jr.
Virginia State University
Petersburg, Va. 23806

Ms. Kathryn Benton Wyatt
301 Magnolia Dr.
Danville, Va. 22454

James E. York, Jr.
1006 Baywood Court
Richmond, Va. 23226

REGULAR MEMBERS

Mr. Steven Ackerman
Biological Sciences Department
Old Dominion University
Norfolk, Va. 23508

Ms. Jean D. Acton
Biology Department
James Madison University
Harrisonburg, Va. 22807

Mr. Arthur A. Adams, III
Physics Department
Virginia Military Institute
Lexington, Va. 24451

Dr. Harold S. Adams
Mtd Route, Box 61-A
Cliftwood Circle
Clifton Forge, Va. 24422

Dr. Robert E. Adams
Forestry & For. Prods.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Curtiss S. Adkisson
Biology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Ms. Karen P. Adkisson
Roanoke College
Salem, Va. 24153

Mr. Frank I. Akers
4935 Lantern St.
Roanoke, Va. 24019

Ms. Sue Gray Al Salam
5 Christopher Newport Drive
Newport News, Va. 23601

Mr. Raymond W. Alden, III
1144 Craftsman Drive
1314 Melrose Parkway
Norfolk, Va. 23508

Dr. James E. Alexander
Route 1, Box 387-A
Pocomoke City, Md. 21851

Richard E. Allan
Route 3, Box 678-A
Ashland, Va. 23005

Dr. William A. Allen
Entomology Department
312 Price Hall, V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. E. Meredith Alrich
University of Virginia Hospital
Charlottesville, Va. 22908

Donna S. Amenta
110 Crescent Drive
Harrisonburg, Va. 22801

Roddy V. Amenta
110 Crescent Drive
Harrisonburg, Va. 22801

American Chemical Society
Dr. David Walsh
A. H. Robins Co., Inc.
1407 Cummings Road
Richmond, Va. 23230

Mr. Don J. Ammerman
Route 1, Box 690
King George, Va. 22485

Dr. Bruce M. Anderson
1013 Highland Circle
Blacksburg, Va. 24060

Dr. Samuel Anderson
2401 Corpyew Ave.
Norfolk, Va. 23504

Mr. Robert L. Andrews
2018 Grove Avenue
Richmond, Va. 23220

Mr. Robert G. Armstrong
10372 Ashburn Rd.
Richmond, Va. 23235

Dr. Jesse C. Arnold
Statistics Department, V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. George C. Ashby, Jr.
217 Milstead Rd.
Newport News, Va. 23606

Mr. John T. Ashworth
P.O. Box 899
Hopewell, Va. 23860

Dr. Carle Aspliden
Envir. Science Department
Brook Hall, University of Virginia
Charlottesville, Va. 22903

Dr. Robert C. Atkins
Chemistry Department
James Madison University
Harrisonburg, Va. 22807

Dr. Robert C. Atkins
Chemistry Department
James Madison University
Harrisonburg, Va. 22807

Dr. Herbert M. Austin
Star Route, Box 31
Gloucester Point, Va. 23062

John M. Austin
1001 Seventh Ave.
Farmville, Va. 23901

Mr. Clinton W. Baber
1101 West Ave.
Richmond, Va. 23220

Dr. Howard W. Baemler
1124 Lexan Ave.
Norfolk, Va. 23508

Mr. J. Rex Baird
Biology Department
Clinch Valley College
Wise, Va. 24293

Mr. Clark P. Baker
4974 Quebec St., NW
Washington, D.C. 20016

Mr. Charley W. Banks
1316 Cedar Lane
Norfolk, Va. 23508

Mr. William I. Banks
6204 Elmshadow Court
Richmond, Va. 23231

Dr. William L. Banks, Jr.
Biochemistry Department
M.C.V. Station
Richmond, Va. 23219

Col. William H. Barba
1308 Lakeview Dr.
Virginia Beach, Va. 23455

Patrick G. Barber
Route 2, Box 29-B
Keysville, Va. 23947

Dr. R. Edward Barker, Jr.
Materials Science Department
Thornton Hall
University of Virginia
Charlottesville, Va. 22903

Dr. Dennis W. Barnes
12 Gildersleeve Rd.
Charlottesville, Va. 22903

Ms. Elizabeth T. Barnes
P.O. Box 791
Buena Vista, Va. 24416

Dr. Lewis B. Barnett
Biochemistry Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. R. W. Barnwell
121 Hertzler Rd.
Newport News, Va. 23602

Prof. Charles E. Bartlett, Jr.
Geology Department
Emory & Henry College
Emory, Va. 24327

Prof. Furman W. Barton
Civil Engineering Department
University of Virginia
Charlottesville, Va. 22901

Dr. Robert G. Bass
901 W. Franklin St. VCU
Richmond, Va. 23284

Dr. Robert C. Bates
Biology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Robert E. Batie
Biology Department
Radford University
Radford, Va. 24142

Dr. R. Wesley Batten
Math Science Center
2200 Mountain Rd.
Glen Allen, Va. 23060

David F. Bauer
Mathematical Sciences Department
Virginia Commonwealth University
Richmond, Va. 23284

Mr. Kenneth H. Baum
Agricultural Economics Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Parker B. Baum
Chemistry Department
Skidmore College
Saratoga Springs, N.Y. 12866

Dr. Harry S. Baumes, Jr.
Agri. Economics Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mrs. Crews B. Baylor
6503 Boatwright Dr.
Richmond, Va. 23226

Mr. G. Parker Beadles
303 Flicker Dr.
Richmond, Va. 23227

Kenneth L. Beal
NMFS NOAA F 34, State Fish Pier
Gloucester, Ma. 01930

Dr. Winston L. Beane
Poultry Sci., Hutchison Hall
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. J. Taylor Beard
Mech. & Aero. Engr.
University of Virginia
Charlottesville, Va. 22901

Dr. Noel Beard
Box 715
Hampden-Sydney, Va. 23943

Dr. James D. Beck
Box 501-N
Virginia State University
Petersburg, Va. 23803

Ms. Mariana R. Becker
6568 Stoney Point, So.
Norfolk, Va. 23502

Ms. Mary Lou Beckett
Biological Sciences Department
Old Dominion University
Norfolk, Va. 23508

Dr. Charles E. Bell, Jr.
Old Dominion University
Norfolk, Va. 23508

Dr. Harold M. Bell
708 Circle Drive
Blacksburg, Va. 24060

Mr. Robert H. Bell
6600 Prospect Rd.
Richmond, Va. 23226

Mr. Maxwell A. Bempong
Biomedical Research Center
Norfolk State College
Norfolk, Va. 23504

Dr. Paul Bender
Bridgewater College
Bridgewater, Va. 22812

Mr. Michael L. Bentley, II
3214 Condie Street
Richmond, Va. 23221

Mr. Rolf H. Benzinger
Biology Department
University of Virginia
Charlottesville, Va. 22901

Mr. Stanley Berent
V.A. Medical Center
2215 Fuller Road
Ann Arbor, Mi. 48105

Dr. Edmund Berkeley
42 Canterbury Rd., Bellair
Charlottesville, Va. 22903

Mr. Carl R. Berquist
917 Jackson Drive
Williamsburg, Va. 23185

Mr. Edward Berry
Anatomy Department
Box 709
M.C.V. Station
Richmond, Va. 23298

Prof. Ioannis M. Besieris
1309 Hillcrest
Blacksburg, Va. 24060

Dr. Phillip J. Best
Psychology Department
University of Virginia
Charlottesville, Va. 22901

Dr. Lee Bettenhausen
U.S. Env. Protection Agency
7 Long Lane
Malvern, Pa. 19355

Dr. G. H. Beyer
1415 Highland St.
Blacksburg, Va. 24061

Mr. Ramesh Bhandari
Physics Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Prof. Raymond C. Bice, Jr.
1720 King Mountain Rd.
Charlottesville, Va. 22901

Dr. Kenneth F. Bick
Geology Department
College of William & Mary
Williamsburg, Va. 23185

Dr. C. J. Bier
Box 163, Chemistry
Ferrum College
Ferrum, Va. 24088

Dr. R. H. Bigelow
1217 Fairwater St.
Norfolk, Va. 23508

Dr. Max G. Bilsky
James Madison University
Harrisonburg, Va. 22807

Samuel W. Bingham
702 Broce Dr.
Blacksburg, Va. 24061

Dr. Samuel O. Bird
Box 2241
1622 Westwood Rd.
Charlottesville, Va. 22901

Dr. Michael N. Bishara
736 Crosswood Dr.
Richlands, Va. 24641

Mr. John W. Bishop
Biology Department
University of Richmond
Richmond, Va. 23173

S. William Bishop
P.O. Box 385
Drakes Branch, Va. 23937

Dr. Robert E. L. Black
College of William & Mary
Williamsburg, Va. 23185

Mr. Alex C. Blackburn
Route 1, Box 20-A
Wytheville, Va. 24382

Mr. William A. Blackwell
Electrical Engr. Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Barbara A. Blair
Chemistry Department
P.O. Box P
Sweet Briar, Va. 24595

Dr. Carvel Hall Blair
Math. & Comp. Sciences Department
Old Dominion University
Norfolk, Va. 23508

Mr. Jeffery N. Blanton
Route 2, Box 239-A
King George, Va. 22485

Dr. R. E. Blaser
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Alfred D. Blease
2415 Oregon Ave., S.W.
Roanoke, Va. 24015

Dr. Charles R. Blem
Virginia Commonwealth University
901 W. Franklin St.
Richmond, Va. 23220

Dr. D. Crandall Bliss
Box 448
Randolph-Macon's Women's College
Lynchburg, Va. 24503

J. Richard Bliss
219 N. Woodberry Ave.
Danville, Va. 24541

Mr. Marion C. Blois
Apt. D.
10625 Provincial Drive
Manassas, Va. 22110

Dr. John A. Board
Box 34
M.C.V. Station
Richmond, Va. 23912

Dr. Sandra Boatman
Hollins College, Va. 24020

Dr. Norlyn L. Bodkin
Biology Department
James Madison University
Harrisonburg, Va. 22807

Mr. William H. Bogart, Jr.
Danville Community College
Danville, Va. 24541

Dr. Judy Bond
Biochemistry Department
Medical College of Virginia
Richmond, Va. 23298

Dr. Marvin R. Boots
Box 581
M.C.V. Station
Richmond, Va. 23298

Patricia D. Borkey
6331 Chamberlayne Road
Mechanicsville, Va. 23111

Ms. Cynthia L. Bosco
Virginia Institute of Marine Science
Gloucester Point, Va. 23062

Dr. K. P. Bovard
22 Agnew Hall
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Edward E. Bowden
9106 Gayton Rd.
Richmond, Va. 23229

Dr. David E. Bowker
NASA-Langley Res. Ctr.
M.S. 272
Hampton, Va. 23665

Dr. Paul Boyan
M.C.V. Station
Richmond, Va. 23298

Eric L. Bradley
Biology Department
College of William & Mary
Williamsburg, Va. 23185

Dr. S. Gaylen Bradley
Box 847
M.C.V. Station
Richmond, Va. 23298

Dr. Richard B. Brandt
Box 727
Medical College of Virginia
Richmond, Va. 23219

Dr. Raymond F. Bratton
Route 6, Box 1-A
Charlottesville, Va. 22901

Mr. Warren L. Braun
680 New York Ave.
Harrisonburg, Va. 22801

Stephen G. Breeding
P.O. Box 1671
Wise, Va. 24293

Dr. William J. Breedlove, Jr.
School of Engineering
Old Dominion University
Norfolk, Va. 23508

Dr. David A. Breil
Natural Sciences Department
Longwood College
Farmville, Va. 23901

Ms. Dana A. Brewer
301 Windsong Lane
Hampton, Va. 23666

Mr. William C. Brewington
3810 Peyton Ave.
Richmond, Va. 23224

Dr. Luther K. Brice, Jr.
Chemistry Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. H. F. Brinson
Engr. Mech. Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. John J. Broderick
Physics Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Coy C. Brooks
Tidewater Rec. & Con. Ed. Center
Holland Station
Suffolk, Va. 23437

G. R. Brooks
Biology Department
College of William & Mary
Williamsburg, Va. 23185

Mr. Richard A. Brost
Geophysical Science Department
Old Dominion University
Norfolk, Va. 23508

Mr. David A. Brown
6133 Merrifield Dr.
Richmond, Va. 23225

Mr. Dennis T. Brown
Biology Department
Mary Baldwin College
Staunton, Va. 24401

Mr. Irby H. Brown
7669 Elkhart Rd.
Richmond, Va. 23235

Mr. Ramon Cintron Brown
3707 Cascade Rd.
Jacksonville, Fl. 32207

Dr. William R. Brown
5671 Pin Oak Ct.
Virginia Beach, Va. 23462

Prof. J. Mark Brubaker
Eastern Mennonite College
Harrisonburg, Va. 22801

Dr. Kenton K. Brubaker
Eastern Mennonite College
Harrisonburg, Va. 22801

Earl H. Brunger
2515 Northfield Rd.
Charlottesville, Va. 22901

W. Roger Buck, III
Gloucester Point, Va. 23062

Dr. Arthur L. Buikema
Biology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

- Alice Louise Bull
Hollins College
Hollins College, Va. 24020
- Dr. Harold E. Burkhardt
Div. of For. & Wildlife Sciences
V.P.I. & S.U.
Blacksburg, Va. 24061
- Robert G. Burnley
Route 6, Box 303
Roanoke, Va. 24014
- Thomas R. Burrus
P.O. Box 114
Goochland, Va. 23063
- Mr. Donald O. Buttermore
1519 N. Utah St.
Arlington, Va. 22207
- Dr. John Cairns, Jr.
Center for Envir. Studies
V.P.I. & S.U.
Blacksburg, Va. 24061
- James L. Calver
Box 3667
University Station
Charlottesville, Va. 22903
- F. Howard Campbell, III
James Madison University
Harrisonburg, Va. 22807
- James F. Campbell
131 Horseshoe Dr.
Williamsburg, Va. 23185
- Mrs. Janet W. Campbell
131 Horseshoe Dr.
Williamsburg, Va. 23185
- Mr. H. M. Camper, Jr.
104 S. Sunset Lane
Warsaw, Va. 22572
- Joan R. Campus
1015 West Main St.
Richmond, Va. 23284
- Mr. George C. Canavos
136 Garrett Dr.
Hampton, Va. 23369
- Mr. Gregory M. Capelli
Biology Department
College of William & Mary
Williamsburg, Va. 23185
- Richard O. Carden
Route 2, Box 39
Cumberland, Va. 23040
- James E. Carico
504 Brevard St.
Lynchburg, Va. 24501
- Mrs. Martha S. Carpenter
Leander McCormick Observatory
Box 3818
University Station
Charlottesville, Va. 22903
- Mr. Roscoe O. Carter, III
1152 Surrey Crescent
Norfolk, Va. 23508
- Mr. Joseph C. Casas
14 Graham Drive
Newport News, Va. 23606
- Ms. Deborah Ann Casey
3497 S. Wakefield St.
Arlington, Va. 22206
- Avery Catlin
Pavillion VIII, East Lawn
University of Virginia
Charlottesville, Va. 22903
- Dr. Vittorio Celli
20 Magnolia Dr.
Charlottesville, Va. 22901
- Mr. Peter H. Ceperloy
Physics Department
George Mason University
Fairfax, Va. 22030
- Dr. Barbara F. Chambers
4220 Dandridge Terrace
Alexandria, Va. 22309
- Ms. Winnie Chan
Box 614
M.C.V. Station
Richmond, Va. 23298
- Mr. G. W. Chandler
The Witchcroft
3960 Richardson Road
Virginia Beach, Va. 23455
- Paul E. Chappell
208 W. Hanbury Rd.
Chesapeake, Va. 23320
- Dr. Wilbert E. Chappell
James Madison University
Harrisonburg, Va. 22807
- Dr. Arthur Charlesworth
Mathematics Department
University of Richmond
Richmond, Va. 23173
- Mr. Melvin C. H. Ching
12301 Roaring Brook Court
Richmond, Va. 23233
- Dr. Joseph P. Chinnici
Biology Department
Virginia Commonwealth University
Richmond, Va. 23220
- Dr. Kuldip P. Chopra
1372 Little Neck Rd.
Virginia Beach, Va. 23452
- Dr. Vincent J. Ciccone
3207 Norwich Terrace
Alexandria, Va. 22309
- Dr. Alex M. Clark
Box 877, Biophysics Department
M.C.V. Station
Richmond, Va. 23219
- Allen K. Clark
Chemistry Department
Old Dominion University
Norfolk, Va. 23508
- Mr. Ivan O. Clark
819 Le Master Ave.
Hampton, Va. 23669
- Dr. Jack W. Clark
Route 3, Box 24
Riner, Va. 24149
- Dr. Gary A. Clarke
Biology Department
Roanoke College
Salem, Va. 24153
- Mrs. Gladys F. Clarke
120 Campbell Lane
Newport News, Va. 23602
- Dr. James W. Clarke
Stop 928
U.S. Geological Survey
Reston, Va. 22092
- Mr. George William Claus
Biology Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. F. P. Clay, Jr.
Physics Department
Old Dominion University
Norfolk, Va. 23508
- Dr. Stephen C. Clement
Geology Department
College of William & Mary
Williamsburg, Va. 23185
- Dr. Martha Clendenin
Eastern Virginia Med. Auth.
P.O. Box 1980
Norfolk, Va. 23501
- Dr. John V. Clevenger
Lord Fairfax Comm. College
Middletown, Va. 22645
- Eugene M. Cliff
207 Primrose Dr.
Blacksburg, Va. 24060
- Dr. Alan F. Clifford
Chemistry Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Stuart C. Clouch
125 Fairwood Dr.
Richmond, Va. 23235
- Mrs. Gwendolyn Coalter
4301 Old Hundred Rd.
Midlothian, Va. 23113
- Dr. Donald G. Cochran
Entomology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mrs. Dallas W. Cocke
8111 University Drive
Richmond, Va. 23229

Dr. W. Dean Cocking
Biology Department
James Madison University
Harrisonburg, Va. 22807

Mr. Kenneth A. Cole
10019 Whitefield Street
Fairfax, Va. 22030

Dr. Philip H. Coleman
Box 847, Microbiology Department
Medical College of Virginia
Richmond, Va. 23219

Dr. R. A. Coleman
College of William & Mary
Williamsburg, Va. 23185

Ms. Carol R. Collins
Albemarle County Schools
County Office Bldg., Room 310
Charlottesville, Va. 22901

Mr. Eric J. Collins
Biology Department
Wytheville, Va. 24382

Dr. James M. Collins
Box 727, Biochemistry Department
Medical College of Virginia
Richmond, Va. 23219

Col. John D. Collins
213 First St.
Front Royal, Va. 22630

Mr. Peter L. Collins
Anser-Personal
400 Army-Navy Drive
Arlington, Va. 22202

Dr. Germille Colmano
Veterinary Science Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. James F. Conley
1614 Trailridge Rd.
Charlottesville, Va. 22903

Mr. James M. Conroy
Biology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Arthur F. Conway
Biology Department
Randolph-Macon College
Ashland, Va. 23005

Dr. Carolyn Conway
Biology Department
Virginia Commonwealth University
Richmond, Va. 23284

Dr. Karl C. Corley, Jr.
Box 125
Medical College of Virginia
Richmond, Va. 23219

Mr. Lawrence J. Corsa, III
Babcock & Wilcox NNFD
P.O. Box 785
Mailcode 15, Mt. Athos
Lynchburg, Va. 24505

Mr. Charles W. Corwin
612 Sumpter Rd.
Waynesboro, Va. 22980

Dr. Abraham A. Coster
3541 West Braddock Rd.
Alexandria, Va. 22302

Mr. Edwin Cox, III
2209 E. Broad St.
Richmond, Va. 23223

Dr. James L. Cox, Jr.
600 Downing Cr.
Virginia Beach, Va. 23452

Mr. William E. Cox
1903 Shelor Lane
Blacksburg, Va. 24061

Dr. Robert F. Cozzens
3009 N. Tacoma St.
Arlington, Va. 22213

Mr. Hugh C. Crafton, Jr.
1110 Trents Ferry Rd.
Lynchburg, Va. 24503

Dr. Jack A. Cranford
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Charles A. Cravotta, III
3187 Eakin Park Ct.
Fairfax, Va. 22031

Mr. Edward A. Crawford
Hampden-Sydney College
Hampden-Sydney, Va. 23943

Dr. George W. Crawford
205 John Wythe Place
Williamsburg, Va. 23185

Capt. Joseph W. Crawford, Jr.
453 Discovery Rd.
Virginia Beach, Va. 23451

Miss Samuella H. Crim
P.O. Box 87
New Market, Va. 22844

Dr. John B. Crittenden
15 Azalea Drive
Blacksburg, Va. 24060

Ms. Leanna Jean Crosby
2465 Williston Drive
Charlottesville, Va. 22901

Dr. Gerald H. Cross
101 Cheatham
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. James T. Crowe, Jr.
1710 Wilmington Ave.
Richmond, Va. 23227

Prof. Thomas I. Crowell
Chemistry Department
University of Virginia
Charlottesville, Va. 22903

Mr. F. L. Crownfield, Jr.
Physics Department
College of William & Mary
Williamsburg, Va. 23185

Mr. Melvin E. Cruser, Jr.
5305 Lakeside Dr.
Virginia Beach, Va. 23451

Dr. Benji T. Cullen, Jr.
Box 233, M.C.V. Station
Richmond, Va. 23298

Dr. Milton D. Cummins
5500 Monument Ave.
Richmond, Va. 23226

Dr. Stephen G. Cuschalk
School of Engineering
Old Dominion University
Norfolk, Va. 23508

Prof. James W. Curley
Longwood College
Farmville, Va. 23901

Dr. William T. Dabney, III
P.O. Box 54
Medical College of Virginia
Richmond, Va. 23219

Dr. Muriel Dahlgard
P.O. Box 455
Randolph-Macon Women's College
Lynchburg, Virginia 24503

Dr. Harry P. Dalton
9500 Tuxford Rd.
Richmond, Va. 23235

William H. Dancy, Jr.
Route 4, Box 308
Charlottesville, Va. 22901

Mr. Daniel M. Daner
Biological Sciences Department
Old Dominion University
Norfolk, Va. 23508

Mrs. Margaret F. Daniel
21 Bostwick Lane
Richmond, Va. 23226

Dr. Van W. Daniel, III
Cinch Valley College
Wise, Va. 24293

Col. Vincent E. Daniel
1169 Northampton Rd.
Petersburg, Va. 23803

Dr. Dennis A. Darby
Geophysical Science Department
Old Dominion University
Norfolk, Va. 23508

Ms. Geraldine C. Darden
512 Lee Street
Hampton, Va. 23669

- Mr. Hubert J. Davis
403 Leavell Road
Portsmouth, Va. 23701
- Dr. John Staige Davis, IV
School of Medicine
University of Virginia
Charlottesville, Va. 22908
- Dr. Frank P. Day, Jr.
1312 Milton St.
Norfolk, Va. 23505
- Ms. Alice Deal
920 Baldwin Ave.
Norfolk, Va. 23507
- Dr. Bascom S. Deaver, Jr.
Physics Department
University of Virginia
Charlottesville, Va. 22903
- Mrs. Rebecca Ross Dechow
Route 2, Box 224-B
Fincastle, Va. 24090
- Dr. R. Dean Decker
Biology Department
University of Richmond
Richmond, Va. 23173
- Dr. J. H. Dedrick
7618 Cornwall Rd.
Richmond, Va. 23229
- Dr. Adarsh Deepak
IFAORS, P.O. Box P
Hampton, Va. 23666
- Ms. Patricia L. Dementi
7519 Oakmont Drive
Richmond, Va. 23228
- Dr. James E. Dendinger
Biology Department
James Madison University
Harrisonburg, Va. 22807
- Dr. J. N. Dent
Biology Department
University of Virginia
Charlottesville, Va. 22903
- Dr. Thomas C. Devore
319 Sixth Street
Harrisonburg, Va. 22801
- Dr. Lovell K. Dewey
P.O. Box 899
Hopewell, Va. 23860
- Dr. William L. Dewey
Pharmacology Department
SISA, Inc.
763 Concord Ave.
Cambridge, Ma. 02138
- Dr. Thomas E. DeWolfe
Box 133
Hampden-Sydney, Va. 23943
- Dr. Charles H. Dickens
1103 Gladstone Place
Wellington, Va. 22308
- Mr. John J. Dieckmann
Dunham Bush Inc.
101 Burgess Rd.
Harrisonburg, Va. 22801
- Dr. Fred A. Diehl
Biology Department
University of Virginia
Charlottesville, Va. 22903
- Mr. David H. Dike
1585 Wesleyan Drive
Norfolk, Va. 23502
- Mr. John G. Dillard
Chemistry Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Mumtaz A. Dinno
Physics Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Dennis M. Dixon
Biology Department
Loyola College
4501 S. Charles St.
Baltimore, Md. 21210
- Prof. Cirila Djordjevic
216 Kingswood Drive
Williamsburg, Va. 23185
- Dr. Gary Hobson Dobbs, III
Biology Department
Washington & Lee University
Lexington, Va. 24450
- Col. S. W. Dobyns
Civil Engr. Department
Virginia Military Institute
Lexington, Va. 24450
- Mr. Thomas W. Doggins
7 Janis Drive
Yorktown, Va. 23692
- Dr. James J. Donaghy
Physics Department
Washington & Lee University
Lexington, Va. 24451
- Mrs. Johanna B. Donaldson
3020 North Edison Street
Arlington, Va. 22207
- Sr. Anne Donigan
P.O. Box 159, Jamestown Road
Williamsburg, Va. 23185
- Mr. Clark S. Donley
1501 Nottoway Avenue
Richmond, Va. 23227
- Mrs. John Van N. Dorr, II
4982 Sentinel Dr., Apt. 304
Sumner Village
Bethesda, Md. 20016
- Dr. J. Mark Dorrepaal
Math & Computer Science Department
Old Dominion University
Norfolk, Va. 23508
- Sr. Louise Dowgiallo
St. Gertrude's High School
3215 Stuart Avenue
Richmond, Va. 23221
- Dr. Charles R. Drake
Va. Agri. Experiment Station
Blacksburg, Va. 24061
- Mr. Stephen W. Drew
Chem. Engr. Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Judy Anne Driskell
Human Nutr. & Food Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. John E. Duberg
NASA LRC NS103
Hampton, Va. 23665
- Mr. Raymond D. Dueser
Environmental Science Department
University of Virginia
Charlottesville, Va. 22903
- Ms. Jeanne L. Dughi
812 St. Luke St.
Virginia Beach, Va. 23455
- Mrs. Scherer S. Duke
301 N. Laburnum Ave., #4
Richmond, Va. 23223
- Dr. Robert L. Duncan
8204 Notre Dame Drive
Richmond, Va. 23228
- Prof. Donald R. Dunn
416 Aspen Drive
Newport News, Va. 23603
- Mr. Preston L. Durrill
Box 5782
1309 Madison Street
Radford, Va. 24141
- Prof. David W. Dwight
Materials Engr. Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Dolores D. Eanes
Route 1, Box 913
Fieldale, Va. 24089
- Daniel Easter
3960 Campbell Road
Newport News, Va. 23602
- Dr. Ralph Eckerlin
8333 Little River Turnpike
Annandale, Va. 22003
- Mr. William J. Edmonds
1610 Kennedy Ave.
Blacksburg, Va. 24060
- Dr. R. S. Edmundson
1707 Kenwood Lane
Meadowbrook Heights
Charlottesville, Va. 22901

Dr. Caroline Edwards
Physiology Department
Route 1, Box 521
Sandston, Va. 23150

Dr. Leslie E. Edwards
Physiology Department
Route 1, Box 521
Sandston, Va. 23150

Ms. Susan Spencer Edwards
P. O. Box 856
Blacksburg, Va. 24060

Mr. John H. Elder, Jr.
Route 10, Box 452
Fredericksburg, Va. 22401

Klaus D. Elgert
Biology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Robert W. Elias
Biology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Walter Elias, Jr.
4223 Hickory Road
Ettrick, Va. 23803

Miss Virginia C. Ellett
Mathematics-Science Center
2401 Hardman Street
Richmond, Va. 23223

Harry V. Ellis, Jr.
Paul D. Camp Comm. College
P.O. Box 737
Franklin, Va. 23851

Mr. Tom Steele Ellis
Northern Virginia Comm. College
Annandale, Va. 22003

Prof. Robert Lee Ellison
Environmental Science Department
University Station
Charlottesville, Va. 22903

Dr. David G. Elmes
Psychology Department
Washington & Lee University
Lexington, Va. 24450

Mr. Lyman R. Emmons
Biology Department
Washington & Lee University
Lexington, Va. 24450

Dr. Michael G. Emsley
4400 University Drive
Fairfax, Va. 22030

Mr. Gerald L. Engel
P.O. Box 602
Gloucester Point, Va. 23062

Thomas Henry Epps
6718 Philbrook Rd.
Richmond, Va. 23234

Prof. L. Ivan Epstein
Biophysics Department
Medical College of Virginia
Richmond, Va. 23219

Dr. William D. Ergle
5941 Castle Rock Road, S.W.
Roanoke, Va. 24018

Carl W. Erkenbrecher
Biological Sciences Department
Old Dominion University
Norfolk, Va. 23508

Dr. Mario Escobar
7708 Vorkdale Dr.
Richmond, Va. 23235

Asim Esen
1500 Westover Dr.
Blacksburg, Va. 24060

Prof. E. O. Essary
Food Science & Tech. Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Henry Evert
P.O. Box 326
Garden City, N.Y. 11530

Mr. Bruce H. Ewald, D.V.M.
Va.-Md. Reg. Col. of Vet. Med.
Blacksburg, Va. 24061

Mr. Thomas E. Ewert
P.O. Box 175
Boyce, Va. 22620

Dr. Joseph D. Exline
Crancy Island Estates
Route 7, Box A-50
Mechanicsville, Va. 23111

Mr. James E. Ezell
7103 Able Road
Chesterfield, Va. 23832

Mr. Wesley M. Fager
520 Redwood Drive
Chesapeake, Va. 23320

Miss Elsa Q. Falls
1515 Helmsdale Drive
Richmond, Va. 23233

Mr. George L. Farris
Route 1
Saltville, Va. 24370

Dr. Norman J. Fashing
Biology Department
College of William & Mary
Williamsburg, Va. 23185

Mr. Randy J. Fear
Box 481
Mt. Jackson, Va. 22842

Mr. Richard D. Fell
Entomology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Peter P. Feret
For. & For. Prod. Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Laurance F. Ferrer
Dairy Science Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mrs. Albert Festa
110 Reservoir Street
Wytheville, Va. 24382

Mr. John R. Ficenece
1305 Glen Core Lane
Blacksburg, Va. 24060

Dr. Paul E. Field
Chemistry Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Robert J. Filer
University of Richmond
Richmond, Va. 23173

Dr. Charles H. Fisher
Chemistry Department
Roanoke College
Salem, Va. 24153

Dr. Sam S. Fisher
722 Shamrock Road
Charlottesville, Va. 22901

Dr. Raymond O. Flagg
712 West Davis Avenue
Burlington, N.C. 27215

Mr. Leroy S. Fletcher
Mech. Engr. Department
University of Virginia
Charlottesville, Va. 22901

Dr. T. P. Floridis
P.O. Box 546
Blacksburg, Va. 24060

Dr. Walter S. Flory, Jr.
Biology Department
Box 7325
Wake Forest College
Winston-Salem, N.C. 27106

Miss Pauline F. Fones
204 B Thor Dr.
Richmond, Va. 23229

Dr. J. P. Fontenot
Science Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Allan L. Forbes, M.D.
11312 Farmland Dr.
Rockville, Md. 20852

Dr. James E. Forbes
213 Maryland Ave.
Westfield, N.J. 07090

Mr. W. E. Foreman
Engineering Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Joseph V. Formica
Microbiology Department
Medical College of Virginia
Richmond, Va. 23219

Dr. C. L. Foster, Jr.
1203 Augusta St.
Bluefield, W. Va. 24701

Dr. Dean Foster
Virginia Military Institute
Lexington, Va. 24451

Ms. Joyce C. Foster
Dept. Biochem. & Nutr.
6818 Schroeder Rd., #8
Madison, Wi. 53711

Laurence W. Frederick
L. McCormick Observatory
University of Virginia
Charlottesville, Virginia 22903

Prof. Ruskin Freer
1158 Timberlake Drive
Lynchburg, Va. 24502

Dr. L. Darwin Fretwell
Box 637
M.C.V. Station
Richmond, Va. 23298

Mr. Herbert Friedman
Psychology Department
College of William & Mary
Williamsburg, Va. 23185

Dr. Tsu-Ching Fu
Pharmacology Department
Box 726
Medical College of Virginia
Richmond, Va. 23298

Dr. F. Paul Fuhs
2411 Sunnybrook Rd.
Richmond, Va. 23229

Dr. Helen M. Gager
7313 Tee Circle
Richmond, Va. 23225

Dr. James A. Gaines
Animal Science Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Samuel J. R. Gamble
1366 Timberlake Drive
Lynchburg, Va. 24502

Louis L. Garber
722 Aintree Place
Staunton, Va. 24401

James E. Garrett
1307 Covington Rd.
Colonial Heights, Va. 23834

L. K. Garrettson
Box 666
Virginia Commonwealth University
Richmond, Va. 23298

Norman E. Garrison
Biology Department
James Madison University
Harrisonburg, Va. 22801

Mr. Michael Garstang
Environmental Science Department
Clark Hall
University of Virginia
Charlottesville, Va. 22903

James E. Gates
Biology Department
Virginia Commonwealth University
Richmond, Va. 23284

Dr. E. Scott Geller
Psychology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Ann Grant Gerhardt
Randolph-Macon Women's College
Lynchburg, Va. 24503

Edward L. Gibbon
P.O. Box 3572, F.S. Station
Radford, Va. 24141

Dr. Ronald N. Giese
213 Jones Hall
College of William & Mary
Williamsburg, Va. 23185

Dr. J. Samuel Gillespie, Jr.
Virginia Inst. Sc. Res.
106 North Court
University of Richmond
Richmond, Va. 23173

Dr. Thomas E. Gilmer
Physics Department
Hampden-Sydney College
Hampden-Sydney, Va. 23943

Billy J. Gilpin
1433 Rutland Drive
Virginia Beach, Va. 23454

Robert H. Gilpin
Bedford Road
Cumberland, Md. 21502

Dr. Lynn Glover, III
4064 Deering Hall
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. W. A. Glynn
9307 Classic Road
Glen Allen, Va. 23060

Dr. G. L. Goglia
School of Engineering
Old Dominion University
Norfolk, Va. 23508

Dr. Edwin J. Goller
Chemistry Department
Virginia Military Institute
Lexington, Va. 24450

Dr. I. J. Good
Statistics Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Richard S. Good
20 Orchard Road
Charlottesville, Va. 22901

Ms. Betsy E. Goodman
Area III, Administration Office
730-A Marshall Rd., S.W.
Vienna, Va. 22180

Dr. Bruce K. Goodwin
College of William & Mary
Williamsburg, Va. 23185

Mr. John R. Gordon
Physics Department
James Madison University
Harrisonburg, Va. 22807

Ms. Margaret A. Gordon
Biology Department
James Madison University
Harrisonburg, Va. 22807

Dr. George W. Gorsline
624 Watson Lane, N.W.
Blacksburg, Va. 24060

Eugene V. Gourley
Biology Department
Radford University
Radford, Va. 24142

Prof. E. Sherman Grable
212 College Rd.
Richmond, Va. 23229

Mrs. Elrica S. Graham
708 Wren Drive
Pulaski, Va. 24301

Dr. George C. Grant
Virginia Assoc. Res. Campus
12070 Jefferson Ave.
Newport News, Va. 23606

Dr. Roy F. Gratz
902 Sylvania Avenue
Fredericksburg, Va. 22401

Prof. George A. Gray
304 Franklin Dr., N.E.
Blacksburg, Va. 24060

Dr. Jack D. Graybeal
Chemistry Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Calvin C. Green
Route 1, Box 7
Quinton, Va. 23141

Dr. George G. Green
2504 Meadowbrook Drive
Blacksburg, Va. 24060

- Frank L. Greene
4810 Darlene Street
Richmond, Va. 23234
- Dr. Virginia C. Greene
540 East Rio Rd.
Charlottesville, Va. 22901
- Mrs. Ann B. Gregory
4620 N. 23rd St.
Arlington, Va. 22207
- Dr. G. C. Grender
Geological Science Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Elizabeth Ann Howell Griffin
4817 Rodney Road
Richmond, Va. 23230
- Dr. William R. Grigsby
1715 11th Street
Coralville, Ia. 52241
- Mr. Russell N. Grimes
Chemistry Department
University of Virginia
Charlottesville, Va. 22901
- Dr. James K. Grimm
Biology Department
James Madison University
Harrisonburg, Va. 22801
- Mr. Richard S. Groover
117 Selden Rd.
Newport News, Va. 23606
- Dr. W. B. Gross
1509 Lark Lane, N.W.
Blacksburg, Va. 24060
- Dr. Edgar J. Gunter, Jr.
Mechanical Eng. Department
University of Virginia
Charlottesville, Va. 22903
- Col. O. W. Gupton
Biology Department
Virginia Military Institute
Lexington, Va. 24450
- Dr. Beatrice E. Gushee
Box 9675
Hollins College, Va. 24020
- Dr. Joseph H. Guth
Interscience Research, Inc.
2614 Wyoming Ave.
Norfolk, Va. 23513
- F. C. Gwazdauskas
Dairy Science Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Frederick C. Haase
822 Simkins Lane
Virginia Beach, Va. 23454
- Dr. Elizabeth Hairfield
Mary Baldwin College
Staunton, Va. 24401
- Dr. Maynard G. Hale
Plant Path. & Phys.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. C. Dillard Haley
1 Fairlawn Ave.
Radford, Va. 24141
- Gustav W. Hall
Biology Department
College of William & Mary
Williamsburg, Va. 23185
- John B. Hall, Jr.
1226 Moyer Road
Newport News, Va. 23602
- Dr. Philip L. Hall
Chemistry Department
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Robert M. Hall
4 Saunders Drive
Poquoson, Va. 23662
- Mr. Christopher R. Halladay
1019 Glendale Rd.
Charlottesville, Va. 22901
- Dr. Daniel L. Hallock
Holland Station
Suffolk, Va. 23437
- Dr. Hunter D. Hamlett
20014 Roosevelt Avenue
Colonial Heights, Va. 23834
- Dr. Gary G. Hammer
Box 6070
Christopher Newport College
Newport News, Va. 23606
- Hampden-Sydney College
Attn: Mr. Ronnie Lawhorne
Hampden-Sydney, Va. 23943
- Mr. Darby G. Hand
1062 W-45th St., Apt. B-2
Norfolk, Va. 23508
- Charles Overton Handley, Jr.
Div. of Mammals
U.S. National Museum
Washington, D.C. 20560
- Dr. John W. Happ
Science Division
Shenandoah College
Winchester, Va. 22601
- Dr. E. Rae Harcum
812 Lake Powell Rd.
Williamsburg, Va. 23185
- Mr. James E. Hardcastle
Chemistry Department
Box 23973
Texas Woman's University
Denton, Tx. 76204
- Dr. William J. Hargis, Jr.
Virginia Inst. of Marine Science
Gloucester Point, Va. 23062
- Dr. Alastair V. Harris
205 10th Street
Radford, Va. 24141
- Mr. James F. Harris
4060 B Forest Hills Ave.
Richmond, Va. 23225
- Dr. Louis S. Harris
Box 726
Medical College of Virginia
Richmond, Va. 23298
- Dr. Robert E. Harris
6402 Red Jacket Drive
San Antonio, Tx. 78238
- Dr. J. L. Hart
Biology Department
George Mason University
Fairfax, Va. 22030
- Dr. Z. V. Harvalik
5901 River Drive
Lorton, Va. 22079
- Danny R. Hatch
324 Dodge Drive
Virginia Beach, Va. 23452
- Mr. Dexter S. Haven
336 Lafayette Rd.
Yorktown, Va. 23490
- Dr. J. K. Haviland
Aerospace Eng. Department
University of Virginia
Charlottesville, Va. 22903
- Fred M. Hawkrige
Chemistry Department
Virginia Commonwealth University
Richmond, Va. 23284
- Mr. Bruce P. Hayden
Route 3, Box 319
Charlottesville, Va. 22901
- Miss Leora Hayes
15104 Spruce Rd.
Chester, Va. 23831
- Mr. Robert C. Haynes
1406 Washington Ave.
Fredericksburg, Va. 22401
- Mrs. Thelma C. Heatwole
5110 West Franklin St.
Richmond, Va. 23226
- George M. Hecker
1108 Hanover Avenue
Norfolk, Va. 23508
- Dr. Lowell Heisey
Bridgewater College
Bridgewater Va. 22812

Mr. Richard H. Heisterberg
Physics Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Miles E. Hench
4802 Kensington Ave.
Richmond, Va. 23226

Charles B. Henderson
Atlantic Research Corp.
5390 Cherokee Ave.
Alexandria, Va. 22302

Mr. James E. Henderson
Route 2, Box 138
Concord, Va. 24538

Mrs. Margaret Henderson
2208 Bassett St.
Alexandria, Va. 22308

Eldred H. Hendricks
Div. of Cont. Education
Box 3697
University of Virginia
Charlottesville, Va. 22903

Ester M. Hendrix
1251 N. Gaskins Rd., Apt. B
Richmond, Va. 23233

Mr. William S. Henika
2526 Jefferson Park Ave.
Charlottesville, Va. 22903

Mrs. Dorothy Henley
4520 N.E. 15th Terrace
Ft. Lauderdale, Fl. 33334

Dr. E. G. Henneke
Eng. Sc. & Merch. Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Miss Elizabeth S. Henry
7320 Glenroie Avenue
Norfolk, Va. 23505

Dr. Paul D. Henson
Chemistry Department
Roanoke College
Salem, Va. 24153

Mr. Richard S. Herd
4305 Cub Run Rd.
Chantilly, Va. 22021

Dr. Frank L. Hereford
Office of the President
University of Virginia
Charlottesville, Va. 22903

Dr. John L. Hess
Biochemistry Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Prof. Walter R. Hibbard, Jr.
1403 Highland Circle
Blacksburg, Va. 24060

Dr. Edwin S. Higgins
Biochemistry Department
M.C.V. Station
Richmond, Va. 23219

Mr. Clarence H. Hill
320 Miller St.
Winchester, Va. 22601

Dr. L. Michael Hill
Biology Department
Bridgewater College
Bridgewater, Va. 22812

Trevor B. Hill
228 Longhill Rd.
Williamsburg, Va. 23185

Overton L. Hillsman
5814 Crestwood Avenue
Richmond, Va. 23226

Ms. Karen S. Hines
1302 Tyler Ave., Apt. 400-F
Radford, Va. 24141

Dr. Klaus Hinkelmann
Statistics Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Bruce Hobbs
717 Cargil Lane
Charlottesville, Va. 22901

Mary C. Hobbs
1227 Warren Avenue
Richmond, Va. 23227

Mr. Robert Lee Hodges
1191 Duncan Drive
Williamsburg, Va. 23185

Dr. Stanton F. Hoegerman
Biology Department
College of William & Mary
Williamsburg, Va. 23185

Dr. E. C. Hoff
Medical College of Virginia
M.C.V. Station
Richmond, Va. 23219

Mr. Frederick L. Hoffman
Foxcroft School
Middleburg, Va. 22112

Dr. R. N. Hofmaster
Virginia Truck Exp. Station
Route 1, Box 133
Painter, Va. 23420

Charles T. Holland
109 McLane Avenue
Morgantown, W. Va. 26505

Dr. B. T. Holmes
300 East Third St.
Frankfort, Ky. 40601

Dr. John R. Holsinger
Biology Department
Old Dominion University
Norfolk, Va. 23508

Bernard S. Holt, Jr.
P.O. Box 25099
Richmond, Va. 23260

Dr. Perry C. Holt
Biology Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Paul J. Homsher
Biology Department
Old Dominion University
Norfolk, Va. 23508

Adolf U. Honkala
13415 Woodbriar Ridge
Midlothian, Va. 23113

Mr. John T. Hopkins
157 Colburn Drive
Manassas Park, Va. 22110

Ms. Nancy S. Hoppes
Science Museum of Virginia
2500 West Broad St.
Richmond, Va. 23220

Dr. R. L. Horsburgh
Shenandoah Val. Res. Station
Steeles Tavern, Va. 24476

John F. Hosner
Forestry & Wildlife Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Ali A. Hossani
Blood Bank, Medical College of Virginia
M.C.V. Station
Richmond, Va. 23219

Dr. Charles R. Houska
Metals & Cer. Eng. Department
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Ian D. Howard
Physics Department
Old Dominion University
Norfolk, Va. 23508

Dr. H. S. Hsu
Microbiology Department
Medical College of Virginia
Richmond, Va. 23298

Dr. Rosemary Hubbard
Rosemount College
2807 N. Glebe Rd.
Arlington, Va. 22207

Dr. B. P. Huddle, Jr.
Chemistry Department
Roanoke College
Salem, Va. 24153

Webster R. Hudgins
41 Woodmont Dr.
Chatham Twp., N.J. 07928

Dr. Milos Hudlicky
1005 Highland Circle
Blacksburg, Va. 24060

Mr. Robert C. Hudson
606 N. Broad St.
Salem, Va. 24153

Dr. Robert S. Hufstедler
724 Pennsylvania Avenue
Norfolk, Va. 23508

Miss M. Gweneth Humphreys
Randolph Macon Woman's Col.
Lynchburg, Va. 24504

Dr. Mary E. Humphreys
6 Baker Street
Berlin, Md. 21811

Dr. Louis R. Hundley
Biology Dept.
Virginia Military Institute
Lexington, Va. 24451

Dr. Robert J. Huskey
Biology Dept.
University of Virginia
Charlottesville, Va. 22901

Prof. Yen Pyng Hwu
1295 N. 3rd St.
Wytheville, Va. 24382

Mr. Paul V. Hyer
Va. Inst. of Marine Sci.
Gloucester Point, Va. 23062

Dr. Phillip B. Hylemon
3218 A Elwood Ave.
Richmond, Va. 23221

Dr. F. A. Iachetta
School of Engr. & Ap. Sci.
University of Virginia
Charlottesville, Va. 22901

Mr. William M. Ingham
Physics Dept.
James Madison University
Harrisonburg, Va. 22807

Dr. E. G. Insley
1233 Brent Street
Fredericksburg, Va. 22401

Paul L. Irwin
3419 Landon St.
Lynchburg, Va. 24503

Auzville Jackson Jr.
Robertshaw Controls Co.
1701 Byrd Ave. & 3. Box 26544
Richmond, Va. 23261

Ms. Caroline G. Jackson
Box 906
M.C.V. Station
Richmond, Va. 23298

Dr. Elizabeth B. Jackson
Route 6, Box 300
Farmville, Va. 23455

Dr. James R. Reed & Assoc.
Biology Dept.
813 Forest Drive
Newport News, Va. 23606

Mr. James Richard Jancaitus
1309 Via Villa Nova
Maitland, Fl. 32751

Dr. Leonard E. Jarrard
Box 1067
Lexington, Va. 24450

Dr. Betty L. Jefferson
4708 Ferry Plantation Circle
Virginia Beach, Va. 23455

Dr. Jackson E. Jeffrey
Biology Dept.
Va. Commonwealth University
Richmond, Va. 23284

Dr. David Jenkins
Physics Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Marie M. Jenkins
Route 2, Box 19 B 1
Strasburg, Va. 22657

Dr. Robert E. Jenkins
Biology Dept.
Roanoke College
Salem, Va. 24153

Dr. Donald R. Jensen
Statistics Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. T. A. Janssen
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. William A. Jessor
Materials Science Dept.
University of Virginia
Charlottesville, Va. 22903

Dr. David T. John
Box 847
Medical College of Va.
Richmond, Va. 23298

Dr. Alva H. Johnson
361 Gainsborough Road
Virginia Beach, Va. 23462

Mrs. Barbara H. Johnson
P. O. Box 1035
Gloucester, Va. 23061

Dr. G. H. Johnson
105 Caron Road
Williamsburg, Va. 23185

Mr. Howard R. Johnson
Rt. 1, Box 231
Blacksburg, Va. 24060

Dr. J. C. Johnson
Biological Sciences Dept.
Old Dominion University
Norfolk, Va. 23508

Dr. James H. Johnson
Anatomy Dept.
Medical College of Va.
Richmond, Va. 23298

Mr. James R. Johnson
6012 N. Belt. West
Belleville, Il. 62223

Dr. L. B. Johnson Jr.
Route 1, Box 202
Charlottesville, Va. 22901

Dr. Miles F. Johnson
Biology Dept.
Va. Commonwealth University
Richmond, Va. 23284

Dr. Preston B. Johnson
1005 Briarwood Point
Virginia Beach, Va. 23452

Dr. Robert A. Johnson
Materials Science Dept.
University of Virginia
Charlottesville, Va. 22903

Dr. Robert W. Johnson
Mail Stop 272
NASA-Langley Research Center
Hampton, Va. 23665

Dr. Ronald E. Johnson
Inst. of Oceanography
Old Dominion University
Norfolk, Va. 23508

Dr. Norman L. Johnson
NASA, Mail Stop 226
Langley Research Center
Hampton, Va. 23365

Dr. William P. Jollie
Anatomy Dept.
P. O. Box 906
Medical College of Va.
Richmond, Va. 23298

Maj. A. Roland Jones
Route 1, Box 184-C
Huddleston, Va. 24104

Mrs. Betty Wade Jones
1746 Westover Avenue
Petersburg, Va. 23803

Mr. George D. Jones
Box 448
Orange, Va. 22960

Mrs. Joyce Howell Jones
Rt. 1, Box 486
Vinton, Va. 24179

Mr. W. George Jones
Route 4, Box 1101
Danville, Va. 24541

William F. Jones
725 South Main Street
Harrisonburg, Va. 22801

- Dr. Robert L. Jordan
Anatomy Dept.
Box 709
M.C.V. Station
Richmond, Va. 23298
- Dr. Elaine C. Joyce
3308 Country Hill Drive
Fairfax, Va. 22030
- Dr. Maureen M. Julian
Box 9555
Hollins College, Va. 24024
- Mrs. Robert A. Justis III
1501 Old Hundrad Road
Midlothian, Va. 23113
- Dr. Robert C. Kamp
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24060
- Dr. Osama A. Kandil
Mechanical Engr. Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. A. M. Kaplan
Surgery Dept.
Box 629
Medical College of Virginia
Richmond, Va. 23298
- Mrs. Leatrice Kaplan
John Tyler Com. College
Chester, Va. 23831
- Mr. Dwight L. Kaster
8807 Stonewall Road
Manassas, Va. 22110
- Mrs. Jonas B. Katz
4700 Old Richmond Avenue
Richmond, Va. 23226
- Dr. Glen M. Kauffman
Eastern Mennonite College
Harrisonburg, Va. 22801
- Dr. James J. Kauzlarick
Mech. Eng. Dept.
University of Virginia
Charlottesville, Va. 22903
- Mr. Lloyd S. Keafer Jr.
Mail Stop 364
NASA-Langley Research Center
Hampton, Va. 23665
- Dr. Robert H. Kean
4800 Fillmore Avenue
Apt. 704
Alexandria, Va. 22311
- Dr. William Keefe
1104 West Avenue
Richmond, Va. 23220
- Dr. F. G. Keihn
1551 Central Avenue
Harrisonburg, Va. 22801
- Dr. Eleanor E. Kemp
Box 5960
Radford University
Radford, Va. 24141
- Mr. John H. Kepchar
Sutherlin Academy
Route 2, Box 516
Danville, Va. 24541
- Walden R. Kerns
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. G. S. Khandelwal
Physics Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. Richard L. Kiefer
College of William & Mary
Williamsburg, Va. 23185
- Dr. Robert B. Kiefer
10902 Maple Street
Fairfax, Va. 22030
- Ms. Linda R. Kilch
Dept. Estaurine Proc.
Va. Inst. of Marine Sci.
Gloucester Point, Va. 23062
- Dr. S. J. Kilpatrick
Box 923
M.C.V. Station
Richmond, Va. 23219
- Mr. Burton F. Kiltz
1713 Bellevue Ave.
Apt. C 602
Richmond, Va. 23227
- Dr. Daniel Kimbrough
10300 Waltham Drive
Richmond, Va. 23233
- Archer Emmet King III
P. O. Box 9898
Norfolk, Va. 23505
- Dr. Bruce L. King
309 Arlington St., Apt. 81
Ashland, Va. 23005
- Mr. & Mrs. H. E. King
Psychology Dept.
Washington & Lee Univ.
Lexington, Va. 24450
- Dr. Paul H. King
Civil Engineering Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Richard W. King
2917 Pine Spring Road
Falls Church, Va. 22042
- Dr. Raymond H. Kirby
961 Lark Away Ct.
Virginia Beach, Va. 23462
- Mr. Robert D. Kirchner
7602 Cornwall Rd.
Richmond, Va. 23229
- Dr. Paul W. Kirk Jr.
Biology Dept.
Old Dominion University
Norfolk, Va. 23518
- Ms. Kathryn Kirkpatrick
2925 Rivermont Avenue, #14
Lynchburg, Va. 24503
- Dr. Roy L. Kirkpatrick
Fisheries & Wildlife Sc. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Franklin D. Kizer
Rt. 2, Box 637
Lancaster, Va. 22503
- Dr. Edward S. Kline
Biochemistry Dept.
Medical College of Va.
Richmond, Va. 23219
- Dr. Genevieve M. Knight
P. O. Box 6613
Hampton Institute
Hampton, Va. 23668
- Dr. James W. Knight
Animal Science Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. C. Barry Knisley
Biology Dept.
Randolph Macon College
Ashland, Va. 23005
- Dr. Robert K. Kobas
Chemistry Dept.
Va. Commonwealth University
Richmond, Va. 23281
- Mr. Carl F. Koch
1315 Surrey Crescent
Norfolk, Va. 23508
- Dr. L. T. Kok
Entomology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Irwin R. Konigsberg
Biology Dept.
Gilmer Hall
University of Virginia
Charlottesville, Va. 22901
- Mr. Mitchell Koppelman
Georgia Kaolin Research
25 Route 22 East
Springfield, NJ 07081
- Ervin T. Kornegay
Animal Science Dept.
V.P.I. & S.U.
Blacksburg, Va. 24601

- Dr. Michael Kosztarab
Entomology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Samuel J. Kozak
Geology Dept.
Washington & Lee Univ.
Lexington, Va. 24450
- Dr. Thomas H. Krakauer
RFD 3, Box 622
Troutville, Va. 24175
- Dr. Richard J. Krieg Jr.
Anatomy Dept.
Box 906
M.C.V. Station
Richmond, Va. 23298
- Mrs. Lois S. Kriegman
26 Malvern Avenue
Richmond, Va. 23226
- John E. Kroll
133 Sir Oliver Road
Norfolk, Va. 23505
- Dr. W. Kroontje
Agronomy Dept.
244 Smith
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. John M. Kuhlman
Mech. Engr. Dept.
Old Dominion University
Norfolk, Va. 23508
- Don C. Kunze
Box 4195
Roanoke, Va. 24015
- Mrs. Lynne Kunze
Va. Western Community Col.
Roanoke, Va. 24015
- Dr. Chin Y. Kuo
Civil Engineering Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mrs. Cornelis Laban
508 South Boulevard
Petersburg, Va. 23803
- Dr. O. W. Lacy
452 Race Street
Lancaster, Pa. 17603
- Mr. John H. Lalor
7655 Sprengle Court
Richmond, Va. 23228
- Mr. Robert G. Lamb
257 Philray Road
Richmond, Va. 23235
- W. Dennis Lamm
Animal Sciences Dept.
14 Agnew
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Morton H. Lancaster
10602 Chipewynn Drive
Richmond, Va. 23233
- Mr. Fred Landa
2119 Unicorn Lane
Richmond, Va. 23235
- Charles F. Lane
Longwood College
Farmville, Va. 23901
- James A. Lanier II
Va. Inst. of Marine Sci.
Gloucester Point, Va. 23062
- Dr. M. A. Latheef
Box 48
Virginia State University
Petersburg, Va. 23803
- Dr. Kenneth R. Lawless
Thornton Hall
University Station
Charlottesville, Va. 22903
- Dr. James D. Lawrence
16 Carroll Drive
Poquoson, Va. 23362
- Mrs. Sue C. Lawrence
16 Carroll Drive
Poquoson, Va. 23362
- Dr. James J. Leary
Chemistry Dept.
James Madison University
Harrisonburg, Va. 22807
- Dr. R. V. Lechowich
Food Sci. & Tech. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. H. M. Lee
Box 57
Medical College of Va.
Richmond, Va. 23219
- Dr. Philip C. Lee Jr.
Route 1, Box 452
Daleville, Va. 24083
- Mrs. Annie S. Leeper
6727 Stuart Avenue
Richmond, Va. 23226
- Dr. F. B. Leftwich
4409 Wister Rd.
Richmond, Va. 23228
- Mr. James D. Lehman
1180 Shenandoah St.
Harrisonburg, Va. 22801
- Mr. A. T. Leighton Jr.
Poultry Science Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Marvin Lentner
410 A Hutcheson
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Charles A. Leonard
A. H. Robins Research Labs
1211 Sherwood Ave.
Richmond, Va. 23220
- Prof. William A. Leuschner
Forestry Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Bernard H. Levin
Blue Ridge Community College
Box 80
Weyers Cave, Va. 24486
- Neal T. Levin
623 Hamilton Rd.
South Orange, NJ 07079
- Gerald F. Levy
Biological Sciences Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. Clark H. Lewis
716 Dickerson Lane
Blacksburg, Va. 24060
- Donald Lightfoot
Biochemistry & Nutr. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Woodfin V. Ligon Jr.
General Electric Co.,pany
2251 Van Antwerp Road
Schenectady, NY 12309
- Dr. L. U. Lilleleht
Thornton Hall
University of Virginia
Charlottesville, Va. 22901
- Dr. David R. Lincicome
Frogmore Farm Box 634
Fort Valley Route
Seven Fountains, Va. 22653
- Mrs. Cheryl Ann Lindeman
109 Yale Street
College Park
Lynchburg, Va. 24502
- Dr. Joseph A. Lineweaver
Dairy Science Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Michael L. Link
PLPP Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Arthur E. Linkins
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Leonidas R. Littleton
Emory, Va. 24327
- Mr. Clement Llewellyn
4030 Sheningham Rd.
Richmond, Va. 23235

- Dr. Gerald Llewellyn
2107 Dresden Rd.
Richmond, Va. 23229
- C. Hardy Long
1501 Palmer Drive
Blacksburg, Va. 24060
- Mr. J. S. Long
Rt. 4, Box 111 E
Powhatan, Va. 23139
- Dr. William B. Looney
Box 392
University of Va. Hospital
Charlottesville, Va. 22908
- Mr. Columbus E. Lord
200 N. Adams St., 329
Arlington, Va. 22201
- Dr. Richard W. Lounsbury
Geology Dept.
Memphis State University
Memphis, TN 38152
- Mr. M. R. Louthan Jr.
1409 Hillcrest Dr.
Blacksburg, Va. 24060
- Dr. David Aaron Lowitz
4312 W. Franklin St.
Richmond, Va. 23221
- Dr. Ralph A. Lowry
Thorton Hall
University of Virginia
Charlottesville, Va. 22901
- Dr. W. D. Lowry
607 Rose Avenue
Blacksburg, Va. 24060
- Mr. J. Richard Lucas
Mining & Minerals Engr. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Philip C. Lucas
302 Crestfield Ct.
Charlottesville, Va. 22901
- Dr. Robert E. Ludt
Chemistry Dept.
Virginia Military Institute
Lexington, Va. 24450
- Dr. John C. Ludwick
Inst. of Oceanography
Old Dominion University
Norfolk, Va. 23508
- Dr. Anne C. Lund
602 Fourth Avenue
Farmville, Va. 23901
- Mr. Robert Dwayne Lunsford
10200 Warren Road
Glen Allen, Va. 23060
- Dr. Charlene M. Lutes
Biology Dept.
Box 5792
Radford University
Radford, Va. 24142
- Frederick H. Lutze
110 Camelot Ct. Oak Manor
Blacksburg, Va. 24060
- Howard A. MacCord Sr.
562 Rossmore Rd.
Richmond, Va. 23225
- Dr. Donald L. MacFadden
Biology Dept.
King College
Bristol, Tenn. 37620
- Mrs. Daniel P. MacLean
420 Cold Spring Road
Virginia Beach, Va. 23454
- Mr. Francis L. Macrina
Box 678
M.C.V. Station
Richmond, Va. 23298
- Dr. Allen H. Magnuson
1101 Gulfview Drive
Blacksburg, Va. 24060
- Dr. Valiant W. Mah
112 Haven Drive
Radford, Va. 24141
- Dr. Bernard L. Mahoney
Box 1631, Chem. Dept.
Mary Washington College
Fredericksburg, Va. 22401
- Dr. R. Wayne Major
1707 Hollandale Ave.
Richmond, Va. 23233
- Alan Mandell
421 Bobby Jones Dr.
Portsmouth, Va. 23701
- Dr. Charlotte P. Mangum
Biology Dept.
College of William and Mary
Williamsburg, Va. 23185
- Dr. Raymond B. Manning
Div. of Crustacea
Smithsonian Institution
Washington, DC 20560
- Dr. Alexandria Manrov
Tidewater Community College
Frederick Campus
Portsmouth, Va. 23703
- John A. Mapp
116 Matoaka Road
Richmond, Va. 23226
- Prof. Lubow A. Margolena
2912 38th St., N.W.
Washington, DC 20016
- Dr. Harold G. Marshall
Biology Dept.
Old Dominion University
Norfolk, Va. 23502
- Dr. Maryan L. Marshall
Central Va. Com. Col.
P. O. Box 4098
Lynchburg, Va. 24502
- Dr. Billy R. Martin
Pharmacology Dept.
Box 613
M.C.V. Station
Richmond, Va. 23298
- Dr. James H. Martin
4008 Bremner Blvd.
Richmond, Va. 23228
- Dr. John W. Martin
Bridgewater College
Bridgewater, Va. 22812
- Dr. Loren G. Martin
Biology Dept.
Virginia Commonwealth University
901 W. Franklin St.
Richmond, Va. 23284
- Dr. R. Bruce Martin
RFD 1 Ardwood Box 223
Earlyville, Va. 22936
- Mr. Michael T. Masnik
USNRC
DSE ESB
Washington, DC 20555
- Dr. J. Philip Mason Jr.
Agr. Engineering, Setz Hall
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. John G. Mason
Chemistry Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. James T. Massey
2016 Cunnell Frames Dr.
Vienna, Va. 22180
- Prof. Joseph W. Mast
Eastern Mennonite College
Harrisonburg, Va. 22801
- Mr. W. H. Matheny
Va. Dept. of Agriculture
203 N. Governor St.
Richmond, Va. 23219
- Robert F. Mathis
Math. & Comp. Sci. Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. James F. Matta
Biology Dept.
Old Dominion University
Norfolk, Va. 23518
- Dr. Martha M. Mattamal
11410 Patriot Lane
Potomac, Md. 20854
- T. L. Matthews Jr.
Beechwood
Route 1, Box 216
Doswell, Va. 23047
- Dr. William J. Matthews
Biology Dept.
Star Route B, Box 205
Kingston, Okla. 73439

- Dr. George Mattus
Agri Exp. Station
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Maurice H. Maxwell Jr.
Natural Sciences Dept.
Longwood College
Farmville, Va. 23901
- Margaret L. May
8104 N. Wilkinson Ct.
Richmond, Va. 23227
- Mr. Richard May
Box 847
M.C.V. Station
Richmond, Va. 23298
- Mr. Thomas T. Mayo IV
P. O. Box 728
Hampden Sydney, Va. 23943
- Mr. Peter M. Mazzeo
U. S. National Arboretum
Washington, DC 20002
- Dr. Freda S. McCombs
600 Buffalo St.
Farmville, Va. 23901
- Edgar P. McConnell
245 Manassas Dr.
Manassas Park, Va. 22110
- Dr. Sara Moss McCowen
4227 Kingcrest Pkwy.
Richmond, Va. 23221
- Mr. Corley P. McDarment
1180 San Juan Drive
Merritt Island, Fl. 32952
- Ms. Anne L. McGivney
8137 Heather MBA #202
Vienna, Va. 22180
- Ms. Donna Lue McGovern
743 Shirley Avenue
Norfolk, Va. 23517
- Dr. Odell S. McGuire
Geology Dept.
Washington and Lee Univ.
Lexington, Va. 24450
- Dr. James E. McIver
1904 Southcliff Rd.
Richmond, Va. 23225
- Virgil V. McKenna
Psychology Dept.
College of William & Mary
Williamsburg, Va. 23185
- Dr. Herbert McKennis, Jr.
Box 923
M.C.V. Station
Richmond, Va. 23219
- Dr. Roger A. McNabb
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Richard P. McNitt
610 Progress St.
Blacksburg, Va. 24060
- Dr. Roger H. Meacham Jr.
1407 Hunter Rd.
Westchester, Pa. 19380
- Dr. J. L. Meem
School of Engineering
University of Virginia
Charlottesville, Va. 22903
- Dr. A. Clair Mellinger
Eastern Mennonite College
Harrisonburg, Va. 22801
- Dr. W. L. Mengebier
Biology Dept.
Bridgewater College
Bridgewater, Va. 22812
- Dr. Donald J. Merchant
2433 Spindrift Road
Virginia Beach, Va. 23451
- Mrs. Jean F. Meredith
Rt. 1, Box F 26
Lyndhurst, Va. 22952
- Dr. Donald A. Merkle
Natural Sciences Dept.
Longwood College
Farmville, Va. 23901
- W. J. Meyer
3206 Landria Dr.
Richmond, Va. 23225
- Dr. Donald L. Michelsen
1597 Inlet Ct.
Reston, Va. 22090
- Dr. Patrick B. Mikesell
Box 5792
Radford University
Radford, Va. 24142
- Mr. John L. Miles Jr.
P. O. Box 125
Churchville, Md. 21028
- Dr. Robert C. Milici
Cons. & Econ. Devel. Dept.
Division of Mineral Resources
P. O. Box 3667
Charlottesville, Va. 22903
- Adolphus J. Miller
Box 474
Virginia State University
Petersburg, Va. 23803
- Mr. Elbert G. Miller
School of Business
Va. Commonwealth University
Richmond, Va. 23284
- Dr. G. Tyler Miller
126 Pleasant Hill Rd.
Apt. B
Harrisonburg, Va. 22801
- Mr. John D. Miller
Route 3, Box 49-1
Tifton, Ga. 21794
- Dr. Lawrence I. Miller
Plant Path. & Phys.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Orson K. Miller, Jr.
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Vernon R. Miller
329 N. Market St.
Salem, Va. 24153
- Mr. Thomas H. Milton
1936 Burks St.
Petersburg, Va. 23803
- Dr. Ralph C. Minehart
Physics Dept.
University of Virginia
Charlottesville, Va. 22903
- Dr. R. B. Minnix
317 Institute Hill
Lexington, Va. 24450
- Dr. Paul D. Minton
2626 Stratford, Rd.
Richmond, Va. 23225
- Dr. John W. Mitchell
327 Kent Rd.
Charlottesville, Va. 22903
- Richard S. Mitchell
Clark Hall
University of Virginia
Charlottesville, Va. 22903
- Dr. Luke W. Mo
Physics Dept.
Robeson Hall
V.P.I. & S.U.
Blacksburg, Va. 24061
- Edward V. Mochel
Mech. Engr. Dept.
University of Virginia
Charlottesville, Va. 22901
- Mrs. Rebecca Mohney
1956 Thomson Rd.
Charlottesville, Va. 22903
- Mr. Stuart B. Monroe
602 Maple Street
Ashland, Va. 23005
- Dr. Lee D. Montroy
50 Hardwick Road
Newport News, Va. 23602
- Mr. Warren L. Moody
6 N. 6th St.
Richmond, Va. 23219
- Prof. Dean T. Mook
Eng. Science & Mech. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. David J. Moore
Box 5937
Radford University
Radford, Va. 24141

Dr. H. Kent Moore
Physics Dept.
James Madison University
Harrisonburg, Va. 22807

Dr. Lawrence D. Moore
Dept. Plant Pathology
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Raymond K. Moore
341 Riggs St.
Dublin, Va. 24084

Mr. William E. Moore
Chemistry Dept.
Norfolk State College
Norfolk, Va. 23504

Dr. Elizabeth D. Mooz
Philip Morris - Res. Center
P. O. Box 26583
Richmond, Va. 23261

Dr. Page S. Morahan
Box 678
Medical College of Va.
Richmond, Va. 23298

Dr. Ben B. Morgan Jr.
Performance Assesment Lab.
Old Dominion University
Norfolk, Va. 23508

Dr. Leonard O. Morrow
7001 Monument Avenue
Richmond, Va. 23226

Dr. Harold S. Morton Jr.
3500 Monocon Dr.
Charlottesville, Va. 22901

Dr. Jeffrey B. Morton
Aerospace Engineering Dept.
University of Virginia
Charlottesville, Va. 22901

Douglas C. Mose
4040 Maple Street
Fairfax, Va. 22030

James N. Moss
213 Wildwood Dr.
Yorktown, Va. 23692

Dr. Wayne A. Moyer
Nat. Assoc. Biol. Teachers
11250 Roger Bacon Drive
Reston, Va. 22090

Mr. Walton Mozingo
Tidewater Res. & Cont. Ed. Ctr.
Holland Station
Suffolk, Va. 23437

Dr. James W. Mullen II
Mantua
Heathsville, Va. 22473

Mr. James L. Mullenex
Math Dept.
James Madison University
Harrisonburg, Va. 22807

Dr. Ruth K. Mulliken
811 Yorkville Road
Yorktown, Va. 23490

Albert E. Munson
7412 Sandlewood Dr.
Richmond, Va. 23235

R. S. Murphey
2300 Chancellor Rd.
Bon Air, Va. 23235

Mr. J. Roy Murphy
15304 Colorado Ave.
Woodbridge, Va. 23191

Dr. Byron K. Murray
Microbiology Dept.
Box 847
M.C.V. Station
Blacksburg, Va. 24060

Mr. William H. Myers
Chemistry Dept.
University of Richmond
Richmond, Va. 23173

Dr. Dean R. Neher
Bridgewater College
Bridgewater, Va. 22812

Bruce J. Neilson
Box 669
Gloucester Point, Va. 23062

Dr. E. Clifford Nelson
Apartment 712
2956 Hathaway Road
Richmond, Va. 23225

Dr. H. I. Nemuth
2012 Monument Ave.
Richmond, Va. 23220

Mr. W. Barlow Newbolt
Washington and Lee Univ.
Lexington, Va. 24450

Mr. Edison E. Newman
2108 Admiral Drive West
Virginia Beach, Va. 23451

Dr. James B. Newman
RFD 1, Box 326-B
Lexington, Va. 24450

Dr. Roberta A. Newton
Box 224
School of Physical Therapy
Medical College of Va.
Richmond, Va. 23298

Dr. John J. Ney
Fish & Wildlife Dept.
106 Julian Cheatham Hall
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Peter T. Nielson
Biology Dept. Box 3156
James Madison University
Harrisonburg, Va. 22807

Mr. A. B. Niemyer, Jr.
4324 Grendell Rd.
Chesapeake, Va. 23321

Dr. Larry A. Nnielsen
101 B. Cheatham Hall
V.P.I. & S. U.
Blacksburg, Va. 24061

Dr. Keith O. Noles
622 Alleghany Avenue
Staunton, Va. 24401

Mr. Edgar J. Nottingham IV
1600 Golden Fields Drive
Memphis, Tenn. 38138

Dr. T. G. Nye
Biology Dept.
Washington and Lee Univ.
Lexington, Va. 24450

James P. B. O'Brien
1700 College Crescent
Virginia Beach, Va. 23456

Mr. James V. O'Connor
U. S. Geological Survey
MS116 MPES Program
Reston, Va. 22092

Dr. F. O. Foghludha
Radiology Dept.
Duke University Medical Center
Durham, NC 27710

Dr. Charles E. O'Rear
2754 Hill Road
Vienna, Va. 22180

Dr. Ronald R. Oetgen
Chemistry Dept.
Roanoke College
Salem, Va. 24153

Dr. George S. Ofelt
824 St. Clement Rd.
Virginia Beach, Va. 23455

Mr. Thomas J. Ogburn III
3220 First Avenue
Richmond, Va. 23222

Douglas W. Ogle
Rt. 1, Box 351
Abingdon, Va. 24210

Dr. Donald M. Oglesby
3213 Little Island Road
Virginia Beach, Va. 23456

Prof. E. J. Oglesby
Box 5145
Charlottesville, Va. 22903

Dr. M. A. Ogliaruso
Chemistry Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

- A. M. Oldham
5700 Oak Street
Mechanicsville, Va. 23111
- Mr. Lee C. Olson
Biology Dept.
Christopher Newport College
Newport News, Va. 23601
- Mr. Walter B. Olstad
208 Marl Ravine Road
Yorktown, V. 23692
- Emil Onuschak Jr.
2712 Bardell Dr.
Sherwood Park II
Wilmington, DE 19808
- Mrs. Ruth O. Opp
8000 North Park St.
Dunn Loring, Va. 22027
- Dr. David M. Orcutt
208 Givens Lane
Blacksburg, Va. 24060
- Prof. Robert A. Orwoll
Chemistry Dept.
College of William & Mary
Williamsburg, Va. 23185
- J. Scott Osborne, Jr.
8904 Alendale Rd.
Richmond, Va. 23229
- Dr. W. Wyatt Osborne
1319 Main St.
South Boston, Va. 24592
- Dr. Raphael M. Ottenbrite
901 W. Franklin St.
Richmond, Va. 23220
- Mr. R. A. Outlaw
98 Cove Rd.
Newport News, Va. 23602
- Mr. Charles H. Owens
Rt. 4, Box 158
Bristol, Tenn. 37620
- Mr. Frank A. Padocsay
Chemistry Dept.
James Madison University
Harrisonburg, Va. 22807
- Dr. John F. Pagels
Biology Dept.
Virginia Commonwealth Univ.
Richmond, Va. 23220
- Dr. Richard A. Palmer
Chemistry Dept.
Old Dominion University
Norfolk, Va. 23508
- Mr. Bruce C. Parker
Biology Dept.
V.P.I. & S. U.
Blacksburg, Va. 24061
- Bernard L. Parsons
Ag. Eng. Dept.
V.P.I. & S. U.
Blacksburg, Va. 24060
- Dr. L. Claire Parsons
2465 Williston Dr.
Charlottesville, Va. 22901
- Dr. William A. Parsons
3412 Ridgewpark Dr.
Broadview Heights, Ohio 44147
- Mr. David W. Partington Jr.
4402 Laurelwood Drive, S. W.
Roanoke, Va. 24018
- Dr. Thomas L. Pasternack
1309 Trent S. Ferry Rd.
Lynchburg, Va. 24503
- Mr. Robert A. Paterson
College of Arts and Sciences
V.P.I. & S. U.
Blacksburg, Va. 24060
- Prof. James B. Patrick
Chemistry Dept.
Mary Baldwin College
Staunton, Va. 24401
- Dr. John L. Patterson Jr.
Box 282
M.C.V. Station
Richmond, Va. 23219
- William Wirt Payne Jr.
Civil Engr. Dept.
Virginia Military Institute
Lexington, Va. 24450
- Dr. William A. Peabody
4805 Brook Road
Richmond, Va. 23223
- Mr. Charles Peachee
9961 Oldfield Drive
Richmond, Va. 23235
- Mr. Carl D. Peacock Jr.
627 Tillar Avenue
Emporia, Va. 23847
- Lucy Byrd Pegau
1808 Winston Road
Charlottesville, Va. 22903
- Pen. Nat. & Sci. Center
Attn: William C. Bradshaw
524 J. Clyde Morris Blvd.
Newport News, Va. 23601
- Mr. C. J. Percival
Norfolk Christian Schools
255 Thole Street
Norfolk, Va. 23505
- Mr. A. P. Perdian
P. O. Box 123
Plainsboro, NJ 08536
- Dr. James Edwin Perham
Biology Dept.
Randolph Macon Woman's Col.
Lynchburg, Va. 24504
- Mr. Timothy W. Perry
7493-9 Prince Charles Court
Manassas, Va. 22110
- Dr. Phillip B. Peters
606 Jackson St.
Lexington, Va. 24450
- Mr. John O. Peterson
313 S. Alfred St.
Alexandria, Va. 22314
- Mrs. Joyce K. Peterson
902 Howard St.
Alexandria, Va. 22304
- Dr. David E. Pettry
Agronomy Dept.
P. O. Box 5248
Mississippi State, Miss. 39762
- Mr. Alvin M. Pettus
College of Education
V.P.I. & S.U.
105 War Memorial Gym.
Blacksburg, Va. 24061
- William G. Pettus
Rt. 2, Box 202
Monroe, Va. 24574
- Dr. Paul V. Phibbs, Jr.
Microbiology Dept.
Box 678
M.C.V. Station
Richmond, Va. 23298
- Jean A. Phillips, II
Human Nutrition & Food Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mrs. Margaret C. Phillips
114 Conway Ave.
Norfolk, Va. 23505
- Dr. Richard L. Phipps
U.S. Geological Survey
Reston, Va. 22092
- Col. George M. Pickral
501 Brooke Lane
Lexington, Va. 24450
- Dr. Roger A. Pielke
Environmental Science Dept.
University of Virginia
Charlottesville, Va. 22903
- Robert L. Pienkowski
Entomology Dept.
V.P.I. & S. U.
Blacksburg, Va. 24061
- Dr. Margaret Pinkston
16 Church Street
Staunton, Va. 24401
- Dr. Mary W. Pinschmidt
8 Nelson St.
Fredericksburg, Va. 22401
- Dr. W. C. Pinschmidt, Jr.
8 Nelson St.
Fredericksburg, Va. 22401
- Peggy Pittas
719 Sherman Drive
Lynchburg, Va. 24502

Dr. Roland R. Pittman
Physiology Dept. Box 608
M.C.V. Station
Richmond, Va. 23298

Dr. Grover C. Pitts
Physiology Dept.
School of Medicine
University of Virginia
Charlottesville, Va. 22903

Dr. Thomas R. Platt
Biology Dept.
University of Richmond
Richmond, Va. 23173

Dr. Patricia Pleban
1181 Clydesdale Lane
Virginia Beach, Va. 23464

Michael A. Pleva
Chemistry Dept.
Washington & Lee Univ.
Lexington, Va. 24450

Mr. S. L. Poe
216 Price Hall
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. James L. Poland
Physiology Dept.
Medical College of Va.
Richmond, Va. 23298

Emory M. Potter
Rt. 2, Box 271
Lexington, Va. 24450

Dr. Lawrence W. Potter
1407 Hill Crest Drive
Blacksburg, Va. 24060

Ms. Tamara S. Powell
The Hunterdale School
Hunterdale Road
Franklin, Va. 23851

Mr. R. Prabhakaran
Mech. Eng. & Mech.
Old Dominion University
Norfolk, Va. 23508

Dr. Anthony J. Provenzano, Jr.
Inst. of Oceanography
Box 6173
Old Dominion University
Norfolk, Va. 23508

Mr. Wolf Prow
23 Warehouse Course
Yorktown, Va. 23692

Mr. Larry J. Puckett
8436 William Glen Court
Manassas, Va. 22110

Dr. Jean E. Pugh
Biology Dept.
Christopher Newport College
50 Shoe Lane
Newport News, Va. 23606

Mrs. Fran Purdum
J. R. Tucker High School
2910 Parham Road
Richmond, Va. 23229

Eugene K. Rader
117 Deerwood Drive
Charlottesville, Va. 22901

Shirley J. Raines
Box 823
Abingdon, Va. 24210

E. W. Ramsey
Rt. 1, Box 123 C
Manakin Sabot, Va. 23103

Mr. Gwynn W. Ramsey
Oak Grove Farm
Route 1, Box 665
Forest, Va. 24551

M. M. Ramsey
126 Observatory Ave.
Charlottesville, Va. 22903

Mrs. Robert W. Ramsey
Physiology Dept.
Box 608
M.C.V. Station
Richmond, Va. 23298

Mr. M. Rangappa
Box 453
Virginia State University
Petersburg, Va. 23803

Mr. Dhanveda M. Rao
Mail Stop 287
NASA-Langley Research Center
Hampton, Va. 23665

Mr. Stanley D. Rasberry
818 Crystal Ct.
Gaithersburg, Md. 20760

Prof. Henry L. Ravenhorst
P. O. Box Drawer 904
Lexington, Va. 24450

Dr. W. M. Reams, Jr.
Biology Dept.
University of Richmond
Richmond, Va. 23173

Dr. John H. Reeves, Jr.
Biology Dept.
Virginia Military Institute
Lexington, Va. 24450

Dr. J. Douglas Reid
Box 124
Irvington, Va. 22480

Dr. Kenneth L. Reifsnider
5 Woodland Hills Drive
Blacksburg, Va. 24060

John J. Reilly
2029 Bishop St.
Petersburg, Va. 23803

Dr. Thomas P. Reinders
Box 581
M.C.V. Station
Richmond, Va. 23298

Ellis E. Remsberg
124 Sleepy Hollow Lane
Grafton, Va. 23692

Dr. R. B. Reneau Jr.
604 Dehart St., S. W.
Blacksburg, Va. 24060

Mr. C. Bruce Rennie
1713 Bellevue Avenue, #613
Richmond, Va. 23227

Dr. Marion R. Reynolds, Jr.
Statistics Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Richard W. Rhodes
307 E. Nash Street
Louisburg, NC 27549

Dr. Nolan E. Rice
Box 169
University of Richmond
Richmond, Va. 23173

Dr. Alfred J. Richard
School of Pharmacy
Medical College of Va.
Richmond, Va. 23219

Mrs. Elias Richards, III
905 Old Trends Ferry Rd.
Lynchburg, Va. 24503

Mr. Walter L. Richards, Jr.
1502 Cedar Lane
Richmond, Va. 23225

Dr. Annie L. Richardson
Norfolk State College
Norfolk, Va. 23504

Dr. Frederic L. Rickett
12521 Easy St.
Chester, Va. 23831

Dr. Bart Van't Riet
School of Pharmacy
Medical College of Va.
Richmond, Va. 23298

Dr. Steven Riethmiller
Chemistry Dept.
Virginia Military Institute
Lexington, Va. 24450

Mr. Bruce Johnson Ripy
P. O. Box 209 A
975 E. Clubhouse Cir. Dr.
Decatur, Ga. 30032

Dr. Paul E. Ritt
36 Sylvan Lane
Weston, Ma. 02193

Dr. Guy Rivers
Biology Dept.
Lynchburg, College
Lynchburg, Va. 24501

- Curtis W. Roane
Plant Path. & Phys. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Martha K. Roane
Dept. Pl. Path. & Physiol.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. James E. Roberts
215 Price Hall
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. William P. Roberts
Geology Dept.
James Madison University
Harrisonburg, Va. 22807
- Dr. Randal M. Robertson
1404 Highland Circle, S.E.
Blacksburg, Va. 24060
- Dr. Andrew Robeson
603 Kelsay Lane, N.W.
Blacksburg, Va. 24060
- Mr. W. Wright Robinson
Box 827
West Point, Va. 23181
- Mr. Richard Rodewald
Biology Dept.
Gilmer Hall
University of Virginia
Charlottesville, Va. 22901
- Dr. Janet A. Rodgers
Nursing Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. Oscar R. Rodig
Chemistry Dept.
University of Virginia
Charlottesville, Va. 22903
- Mr. Gerald C. Roinestad
P. O. Box 278
Winchester, Va. 22601
- Dr. Stan Rola
P. O. Box 269
Melfa, Va. 23410
- Mr. Hugh Rooney
2904 Craigwood Circle
Mechanicsville, Va. 23111
- Mr. Dale E. Rose
729 Beach Road
Hampton, Va. 23664
- A. L. Rosenzweig
4909 Wythe Ave.
Richmond, Va. 23226
- Dr. Fred K. Ross
Chemistry Dept.
V.P.I. & S.U.
Blacksburg, Va. 24060
- Ms. Shirley E. Rosser
Lynchburg College
Lynchburg, Va. 24501
- Dr. Simon Rothberg
Box 127
Medical College of Va.
Richmond, Va. 23298
- Dr. Frederick B. Rowe
Box 487
Randolph Macon Woman's Col.
Lynchburg, Va. 24503
- Dr. Paulette W. Royt
Biology Dept.
George Mason University
Fairfax, Va. 22030
- Mr. Robert T. Ruckart
2221 Devonshire Rd.
Richmond, Va. 23225
- Miss Grace L. Ruffin
2211 East Washington St.
Suffolk, Va. 23434
- Dr. John J. Ruffolo Jr.
Biophysics Dept.
M.C.V. Station
Richmond, Va. 23298
- Dr. Joseph H. Rule
Geophysical Sciences Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. Eric G. S. Rundberg, Jr.
1313 Wilderness Drive
Richmond, Va. 23231
- Lawrence O. Sabatinos
P. O. Box 54
Blacksburg, Va. 24060
- Dr. Mohamed A. Sabet
Geophysical Sciences Dept.
Old Dominion University
Norfolk, Va. 23508
- Sohair F. Sabet
Box 847
Medical College of Va.
Richmond, Va. 23298
- Mr. Alfred E. Saieed
P. O. Box 64
Fairfax, Va. 22030
- Dr. George D. Sands
4 Foxcroft Rd.
Williamsburg, Va. 23185
- Dr. George Sanzone
609 Piedmont
Blacksburg, Va. 24061
- Dr. William C. Sauder
Physics Dept.
Virginia Military Institute
Lexington, Va. 24450
- Robert W. Saum, Sr.
2007 Edgewood Rd.
Ashby Heights
Harrisonburg, Va. 22801
- Mrs. Virginia Saunders
Goodview, Va. 24095
- Mr. Kurt Savoie
1 Gateway East
Richmond, Va. 23229
- Dr. P. F. Scanlon
Div. of For. & Wildlife Ser.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Prof. Paul N. Schatz
Chemistry Dept.
University of Virginia
Charlottesville, Va. 22903
- Mr. Karl A. Schellenberg
1332 Lakeview Drive
Virginia Beach, Va. 23455
- Frances V. Schoomaker
4913 Dodson Drive
Annandale, Va. 22003
- Dr. Henry D. Schreiber
Chemistry Dept.
Virginia Military Institute
Lexington, Va. 24450
- Dr. John C. Schug
RFD 1, Box 431A
Blacksburg, Va. 24030
- Mr. Peter B. Schultz
1444 Diamond Springs Rd.
Virginia Beach, Va. 23455
- Mr. Gerhardt G. Schurig
V.P.I. & S.U. Col. of Vet. Med.
Blacksburg, Va. 24061
- Dr. Karl E. Schwaab, II
316 Gym
V.P.I. & S.U.
Blacksburg, Va. 24061
- Frederick R. Scott
115 Kennondale Lane
Richmond, Va. 23226
- Mr. John E. Scott, Jr.
1875 Wayside Place
Charlottesville, Va. 22903
- Dr. Marvin W. Scott
Chairman, Nat. Sci. Dept.
Longwood College
Farmville, Va. 23901
- Dr. Robert B. Scott
Medical College of Va.
Richmond, Va. 23298
- Dr. Timothy C. Scott
Mech. & Aerospace Engr.
University of Virginia
Charlottesville, Va. 22901

Dr. William W. Scott
Botany Dept.
Eastern Illinois University
Charleston, IL 61920

Dr. Frank E. Scully, Jr.
Chemical Sciences Dept.
Old Dominion University
Norfolk, Virginia 23508

C. E. Sears
Box 522
Blacksburg, Va. 24060

Dr. Hugo R. Seibel
Anatomy Dept.
Medical College of Va.
Richmond, Va. 23219

Prof. Arthur J. Seidenberg
Biology Dept.
Va. Commonwealth University
Richmond, Va. 23284

Cletus M. Sellers, Jr.
Rt. 1, Box 186
Linville, Va. 22834

Mr. Paul J. Seminer
825 S. Main St.
Blackstone, Va. 23824

Dr. Dilip K. Sen
Box 366
Virginia State University
Petersburg, Va. 23803

Mr. Frank A. Settle, Jr.
Rt. 1, Box 367
Lexington, Va. 24450

Dr. Richard G. Seymann
Lynchburg College
Lynchburg, Va. 24501

Mr. Charles D. Seymour
116 Meadow Drive
Hightstown, NJ 08520

Dr. Joseph A. Sgro
1402 Highland Cir., S.E.
Blacksburg, Va. 24060

Dr. H. Jean Shadomy
Box 847
Medical College of Va.
Richmond, Va. 23298

Dr. Smith Shadomy
Box 38
Medical College of Virginia
Richmond, Va. 23298

Vernon O. Shanholtz
Agricultural Engr.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Terry L. Sharik
507 Stonegate Drive
Blacksburg, Va. 24060

Mrs. Betty D. Sharpe
32 Huguenot Road
Newport News, Va. 23606

J. M. Sharpley
Box 846
Fredericksburg, Va. 22401

Dr. Robert G. Shaver
Versar Inc.
6621 Electronic Drive
Springfield, Va. 22151

Mr. Nathaniel Shear
1401 Blair Mill Rd. S.
Silver Spring, Md. 20910

Dr. Douglas H. Shedd
Biology Dept.
Box 475
Randolph Macon Woman's College
Lynchburg, Va. 24504

Mr. Keith R. Shelton
Biochemistry Dept.
Medical College of Va.
Richmond, Va. 23219

Mr. Allen F. Sherald
9451 Lee Highway #1290
Fairfax, Va. 22030

Dr. W. Cullen Sherwood
Geology Dept.
James Madison University
Harrisonburg, Va. 22807

Dr. William A. Sherwood
Biology Dept.
Lynchburg College
Lynchburg, Va. 24504

Mr. Donald D. Shillady
13202 Thornridge Lane
Midlothian, Va. 23113

Dr. James K. Shillington
Box 557
Lexington, Va. 24450

Mr. E. Reiman Shober
Rt. 1 Box 115
Monroe, Va. 24574

Dr. Gilbert R. Shockley
207 Nottingham Rd.
Richmond, Va. 23221

John F. Shoulders
Agri. Ext. Service
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Stephan A. Siegel
130 E. 18th Street
New York, NY 10003

Mrs. Micaela M. Sieraki
308 River Road
Newport News, Va. 23601

Dr. Gene M. Silberhorn
S R Box 230
Goucester Point, Va. 23062

Dr. Beverly P. Silver
1550 Dale Circle
Harrisonburg, Va. 22801

Dr. George M. Simmons
Dept. of Bio., Deering Hall
V.P.I. & S.U.
Blacksburg, Va. 24060

Mr. R. O. Simmons
Chemistry Dept.
James Madison University
Harrisonburg, Va. 22807

Joanne Simpson
P. O. Drawer 5508
Charlottesville, Va. 22903

Miss Margaret Simpson
Box 26
Sweet Briar College
Sweet Briar, Va. 24595

Mr. Robert C. Simpson
Route 1, Box 154B
Charlottesville, Va. 22903

Dr. Robert H. Simpson
P. O. Drawer 5508
Charlottesville, Va. 22903

Rana P. Singh
Mathematic Dept.
Virginia State University
Petersburg, Va. 23803

Ekkehard Sinn
Chemistry Dept.
University of Virginia
Charlottesville, Va. 22901

Dr. Herbert J. Sipe Jr.
Chemistry Dept.
Hampden Sydney College
Hampden Sydney, Va. 23943

Dr. Thomas O. Sitz
Chemical Sciences Dept.
Old Dominion University
Norfolk, Va. 23508

Judith F. Skog
611 Roberts Dr., N.W.
Vienna, Va. 22180

Dr. Laurence E. Skog
611 Roberts Dr., N.W.
Vienna, Va. 22180

Mrs. Frank G. Sloop
Box 601
Dublin, Va. 24084

Dr. B. D. Smith
P. O. Box 1026
Dahlgren, Va. 22448

Dr. Burke M. Smith
Box 348
University of Va. Hospital
Charlottesville, Va. 22908

Dr. Carroll E. Smith
Box 5966
Radford University
Radford, Va. 24141

Dr. Charles D. Smith
Science Museum of Virginia
2500 W. Broad St.
Richmond, Va. 23220

David W. Smith
Sch. of For. & Wildlife Res.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Edward D. Smith
3004 Three Bridges Road
Midlothian, Va. 23113

Dr. Homer A. Smith, Jr.
Box 23
Hampden Sydney, Va. 23943

Dr. J. Doyle Smith
School of Pharmacy
Medical College of Va.
Richmond, Va. 23298

Dr. John C. Smith
400 Kingsale Rd.
Holland Station
Suffolk, Va. 23437

Mr. R. L. Smith
Rt. 3, Box 272 S.
Glen Allen, Va. 23060

Mr. Robert L. Smith
940 West Teak St.
Brea, Calif. 92621

Dr. Albert T. Sneden
Chemistry Dept.
Va. Commonwealth University
Richmond, Va. 23284

Dr. Michael J. Snodgrass
Box 906
M.C.V. Station
Richmond, Va. 23231

Dr. Nickolas J. Sojka
Jordan Building, MEB
1300 Jefferson Pk. Ave.
Charlottesville, Va. 22908

Dr. Stephen D. Southall
3912 Faculty Dr.
Lynchburg, Va. 24501

Mr. Chester Spencer
Holden Hall
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Edgar W. Spencer
Geology Dept.
Washington and Lee Univ.
Lexington, Va. 24450

Dr. Randall S. Spencer
Geology Dept.
Old Dominion University
Norfolk, Va. 23508

Mr. Turner M. Spencer
Biology Dept.
Thomas Nelson Junior College
Hampton, Va. 23366

Dr. Diane Spresser
Math. & Compt. Sci. Dept.
James Madison University
Harrisonburg, Va. 22807

Mr. Arthur M. Squires
2710 Quincy Court
Blacksburg, Va. 24060

Mrs. Jeanne J. Stabler
Tidewater Community College
Frederick Campus
Portsmouth, Va. 23703

H. W. Staley, IV
Box 25
Woodberry Forest, Va. 22989

Prof. Wayne M. Stalick
Chemistry Dept.
George Mason University
Fairfax, Va. 22030

Dr. Vassilios Stamoudis
Energy & Envir. Systems
Bldg. 12, Argonne National Lab.
9700 S. Cass Ave.
Argonne, Ill. 60439

Dr. Conrad Stanitski
Randolph Macon College
Ashland, Va. 23005

Dr. Melissa Stanley
4224 Sideburn Rd.
Fairfax, Va. 22030

Dr. T. M. Starling
Agronomy Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. David E. Starner
Route 4, Box 1752
Christiansburg, Va. 24073

Dr. R. G. Steinhardt, Jr.
Hollins College, Va. 24020

Dr. Orrie O. Stenroos
Biology Dept.
Lynchburg College
Lynchburg, Va. 24504

Dr. N. Thomas Stephens
Civil Eng. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Steven L. Stephenson
1115 Morningstar Lane
Fairmont, W. Va. 26554

Dr. William Stepka
P. O. Box 581
M.C.V. Station
Richmond, Va. 23298

Charles E. Stevens
615 Prestone Pl.
Charlottesville, Va. 22903

Dr. Phyllis W. Stevens
Box 85
Sweet Briar College
Sweet Briar, Va. 24595

Dr. Edward C. Stevenson
Box 1893
University Station
Charlottesville, Va. 22903

Dr. Franklin B. Stewart
1444 Diamond Springs Rd.
Virginia Beach, Va. 23455

Dr. Roberta A. Stewart
Box 9685
Hollins College, Va. 24020

Dr. Edgar F. Stillwell
Biology Dept.
Old Dominion University
Norfolk, Va. 23508

Dr. Wayne W. Stinchcomb
Engr. Science & Mechs.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. R. Jay Stipes
Path. & Physiology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Brian Storrie
Biochem & Nutr. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Ernest R. Stout
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. Carey E. Stronach
2241 Buckner St.
Petersburg, Va. 23803

Mr. H. Winston Stuart, Jr.
1663 Knollwood Drive
Richmond, Va. 23235

Dr. R. D. Stuck
289 Oenoke Ridge
New Canaan, Ct. 06840

Dr. B. L. Stump
2811 Longon Pk. Drive
Midlothian, Va. 23113

Mr. Neal Sumerlin
Chemistry Dept.
Lynchburg College
Lynchburg, Va. 24501

Dr. Richard J. Sundberg
Chemistry Dept.
University of Virginia
Charlottesville, Va. 22903

Ms. Helen C. Sutton
118 Kingsbury Drive
Newport News, Va. 23606

Mr. Harold G. Swain
9129 Patton Boulevard
Alexandria, Va. 22309

Robert R. Swann
4404 Hinsdale St.
Virginia Beach, Va. 23462

- Robert James Swanson
1014 Jamestown Crescent
Norfolk, A. 23508
- Dr. Barry L. Swedlow
3623 Old Forrest Road
Lynchburg, Va. 24501
- Sweet Briar College
Treasurer's Office
Sweet Briar, Va. 24595
- Dr. Edward M. Sweitzer
1018 A Mycroft Court
Sterling, Va. 22170
- Dr. A. K. Szakal
Anatomy Dept.
Box 906
M.C.V. Station
Richmond, Va. 23298
- Mr. Edward W. Sznyter, Jr.
1416 Shamrock Avenue
Virginia Beach, Va. 23455
- Dr. Richard B. Talbot
College of Vet. Medicine
V.P.I. & S.U.
Blacksburg, Va. 24061
- Claude P. Talley
3442 Northview St.
Richmond, Va. 23225
- Dr. Chandley Roy Taylor, Jr.
2715 Fenholloway Dr.
Mechanicsville, Va. 23111
- Ms. Elizabeth B. Taylor
2431 Swathmore Road
Richmond, Va. 23235
- Dr. Gerald R. Taylor Jr.
James Madison University
Harrisonburg, Va. 22807
- Dr. L. H. Taylor
Agronomy Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Larry T. Taylor
Chemistry Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Thomas G. Teates
Rt. 4, Box 1114
Christiansburg, Va. 24073
- Dr. D. P. Telionis
Eng. Sci. & Mech.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Wade J. Temple
Box 661
Ashland, Va. 23005
- Mrs. Eleanor Tenney
1507 Cutshaw Place
Richmond, Va. 23226
- Dr. G. Richard Terman
Biology Dept.
College of William & Mary
Williamsburg, Va. 23185
- Dr. Thomas R. Terrill
Rt. 1, Box 32
Blackstone, Va. 23824
- Mr. Henry C. Terry, Jr.
2720 Hanes Ave.
Richmond, Va. 23222
- Dr. John G. Tew
P. O. Box 847
Richmond, Va. 23298
- Dr. M. D. Tewari
Box 502-N
Virginia State University
Petersburg, Va. 23834
- Mr. John G. Thacker
Mechanical Eng. Dept.
University of Virginia
Charlottesville, Va. 22901
- Mr. H. R. Thomas
Holland Station
Suffolk, Va. 23437
- Mr. John H. Thomas
General Delivery
White Post, Va. 22663
- Mr. Max Thomas
Rt. 4
Floyd, Va. 24091
- Dr. David W. Thompson
Chemistry Dept.
College of William and Mary
Williamsburg, Va. 23185
- Dr. Douglas S. Thompson
1206 Fourth Avenue
Farmville, Va. 23901
- Dr. Ertle Thompson
308 Montebello Circle
Charlottesville, Va. 22903
- Dr. Jesse C. Thompson, Jr.
Biology Dept.
Roanoke College
Salem, Va. 24153
- Dr. Kenneth W. Thompson
Center for Environ. Studies
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Michael K. Thompson
1007 Boulevard
Colonial Heights, Va. 23834
- Paula J. Thompson
Biology Dept., Gilmer Hall
University of Virginia
Charlottesville, Va. 22903
- Dr. Thomas E. Thompson
Biochemistry Dept.
School of Medicine
University of Virginia
Charlottesville, Va. 22908
- Henry W. Tieleman
Eng. Sc. and Mechanics Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Calvin O. Tiller
Route 1
King William Woods Road
Midlothian, Va. 23113
- Mr. Ronald W. Tillman
PL Path. & Physio. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Wayne H. Tinnell
Natural Sciences Dept.
Longwood College
Farmville, Va. 23901
- Ms. Virginia M. Tipton
Biology Dept.
Radford University
Radford, Va. 24142
- Dr. Surendra N. Tiwari
Mech. Engr. Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. Sue A. Tolin
Plant Path. & Physiol. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Tompkins-McCaw Library
Virginia Commonwealth Library
M.C.V. Station
Richmond, Va. 23219
- Dr. M. E. Toney, Jr.
2349 Brook Road
Richmond, Va. 23220
- Mr. Thomas W. Toney
5544-A Pony Farm Drive
Richmond, Va. 23227
- Mr. Max Tongier Jr.
44 Brandon Rd.
Newport News, Va. 23601
- Dr. Richard W. Tophan
11821 Young Manor Drive
Midlothian, Va. 23113
- Dr. Joseph Topick
Chemistry Dept.
Va. Commonwealth University
Richmond, Va. 23284
- Dr. David W. Towle
Biology Dept.
University of Richmond
Richmond, Va. 23173
- Mr. Gilmore Henry Trafford
P. O. Box 36
Wallops Island, Va. 23337

- Dr. Leland E. Traywick
Bureau Business Research
College of William and Mary
Williamsburg, Va. 23185
- Dr. George E. Treadwell, Jr.
P. O. Drawer DDD
Emory, Va. 24327
- Dr. Gilbert S. Trelawny
Box 606
James Madison University
Harrisonburg, Va. 22807
- Mrs. Marguerite S. Trent
1107 Essex Ave.
Richmond, Va. 23229
- I. F. Trew
P. O. Box 127
Crozet, Va. 22932
- Dr. L. James Tromater
Psychology Dept.
University of Richmond
Richmond, Va. 23173
- Dr. W. E. Trout, III
Biology Dept.
City of Hope Medical Ctr.
Duarte, Calif. 91010
- D. W. Peter Trower
Physics Dept.
V. P.I. & S.U.
Blacksburg, Va. 24061
- Dr. E. C. Turner Jr.
Entomology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mrs. Katherine R. Turner
Rt. 3
Bedford, Va. 24523
- Dr. S. Y. Tyree, Jr.
College of William and Mary
Williamsburg, Va. 23185
- Amjad Umari
Civil Engr. Dept.
Old Dominion Univ.
Norfolk, Va. 23508
- Dr. Billy T. Upchurch
Chemistry Dept.
Old Dominion University
Norfolk, Va. 23508
- Granville G. Valentine, Jr.
Box 7306
Richmond, Va. 23221
- Mr. Jacob Van Bowen, Jr.
1714 Bloomfield Road
Richmond, Va. 23225
- Mr. F. M. Van Damme
212 Pine Drive
Blacksburg, Va. 24060
- Dr. Harry P. Van Krey
Poultry Science
Hutchison Hall
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. John D. Van Norman
Chemical Sciences Dept.
Old Dominion University
Norfolk, Va. 23508
- Frances L. Van Scoy
Math & Comp Sc. Dept.
Old Dominion Univ.
Norfolk, Va. 23508
- Willard A. Vanengel
Va. Inst. of Marine Sci.
Gloucester Point, Va. 23062
- Dr. Richard B. Vasey
Div. Forestry & Wildlife Res.
324 Cheatham Hall
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. David H. Vaughan
311 Seitz Agr. Engr.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Virginia Psychological Assoc.
109 Amherst St.
Winchester, Va. 22601
- Virginia Wesleyan College
Wesleyan Drive
Norfolk, Va. 23502
- Dr. William H. Voige
Chemistry Dept.
James Madison University
Harrisonburg, Va. 22807
- Dr. J. Reese Voshell, Jr.
Entomology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Terry L. Wade
Institute of Oceanography
Old Dominion University
Norfolk, Va. 23508
- Dr. Helmut R. Wakeham
8910 Brieryle Road
Richmond, Va. 23229
- Dr. Richard D. Walker
Civil Eng. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- William Edwin Walker
Box 38
Univ. of Richmond, Va. 23173
- Mr. William R. Walker
Water Resources Res. Ctr.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Thomas P. Wallace
770 Suffolk Court
Virginia Tech, Va. 23452
- Dr. Richard V. Waller
Box 263
M.C.V. Station
Richmond, Va. 23298
- Dr. Emmanuel U. Wallerstein
2622 Park Ave.
Richmond, Va. 23220
- Ronald E. Walpole
Roanoke College
Salem, Va. 24153
- Mrs. Martha L. Walsh
Fork Union, Va. 23501
- Dr. C. Robert Walter, Jr.
Chemistry Dept.
George Mason University
4400 University Drive
Fairfax, Va. 22030
- Miss Lucie Walton
1116 Richmond Blvd.
Danville, Va. 24541
- Mr. William U. Walton
Science Museum of Virginia
2500 West Broad Street
Richmond, Va. 23220
- Mr. Ralph C. Wands
4901 Springwood Drive
Raleigh, NC 27612
- Dr. John W. Ward
A. H. Robins Co., Inc.
1407 Cummings Drive
Richmond, Va. 23220
- Dr. Donna Eggers Ware
Biology Dept.
College of William & Mary
Williamsburg, Va. 23185
- Mrs. Elizabeth F. Ware
Chem. Dept.
Northern Va. Com. Col.
8333 Little River Turnpike
Annandale, Va. 22003
- Dr. Stewart A. Ware
Biology Dept.
College of William & Mary
Williamsburg, Va. 23185
- Mrs. James C. Waring
302 Ralston Rd.
Richmond, Va. 23229
- Mr. William Warren
711 St. Christophers Road
Richmond, Va. 23226
- Mr. Clarence E. Waskey
3902 Galena Avenue
Hopewell, Va. 23860

- Dr. Marvin L. Wass
Va. Inst. of Marine Sci.
Gloucester, Va. 23062
- Dr. Marie Waters
Box 5761
Radford University
Radford, Va. 24141
- Miss Leslie V. Watkins
208 N. Bruffey St.
Salem, Va. 24153
- Ms. Ann Darnell Watson
110 S. 4th St.
Suffolk, Va. 33434
- Douglas F. Watson
209 Sunset Boulevard
Blacksburg, Va. 24060
- Dr. William L. Watson
Box 327
Virginia State University
Petersburg, Va. 23806
- Franklin E. Wawner, Jr.
Materials Science Dept.
University of Virginia
Charlottesville, Va. 22901
- Mr. Barron L. Weand
1116 Albin Street
Laramie, WY. 82070
- Mrs. Diana C. Weand
1116 Albin Street
Laramie, WY. 82070
- George R. Webb
12 Briar Patch Place
Newport News, Va. 23606
- Dr. Kenneth L. Webb
Va. Inst. of Marine Sci.
Gloucester Point, Va. 23062
- Mr. Stanley R. Webb
Biology Dept.
Va. Commonwealth University
Richmond, Va. 23284
- Ms. Gretchen Weber
2311 Pimmit Dr., Apt. 1498E
Falls Church, Va. 22043
- Richard S. Weber
2340 Contest Lane
Haymarket, Va. 22069
- Mr. Helmut Wedow
P. O. Box 11542
Knowlville, Tenn. 37919
- Mr. Elie Weeks
Rochambeau
Manakin, Va. 23103
- Dr. John A. Weese
School of Engineering
Old Dominion University
Norfolk, Va. 23508
- Dr. Ronald R. Weik
Biochem. Dept.-Bldg. 139
L.S.U. Med. Center
1100 Florida Ave.
New Orleans, La. 70074
- Elizabeth M. Weiland
1316 Langhorne Rd.
Lynchburg, Va. 24503
- Freya Weizenbaum
Psy. Dept.
5099 Derring Hall
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Christopher S. Welch
Va. Inst. of Marine Sci.
Gloucester Point, Va. 23061
- Dr. Felix P. Welch
Washington and Lee Univ.
Lexington, Va. 24450
- Mr. L. Staton Weldon
NASA Langley Research Center
Langley Air Force Base
Hampton, Va. 23666
- Dr. John C. Wells
James Madison University
Harrisonburg, Va. 22807
- Dr. H. J. Welshimer
Microbiology Dept.
Medical College of Va.
Richmond, Va. 23298
- Dr. William J. Welstead
8306 Brookfield Rd.
Richmond, Va. 23227
- Dr. David A. West
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Ms. Louise A. West
Dental Hygiene Dept.
Old Dominion University
Norfolk, Va. 23508
- Robert L. West
100 C Terrace View
Blacksburg, Va. 24060
- Dr. Thomas C. Westfall
Pharmacology Dept.
University of Virginia
Charlottesville, Va. 22908
- Dr. Stanley I. Wetmore, Jr.
Chemistry Dept.
Virginia Military Institute
Lexington, Va. 24450
- Dr. Robert C. Whisonant
Geology Dept.
Radford University
Radford, Va. 24141
- Dr. A. G. C. White
Biology Dept.
Virginia Military Institute
Lexington, Va. 24451
- Mr. John E. White
Box 129
Bridgewater College
Bridgewater, Va. 22812
- Mr. Larry H. White
Chemistry Dept.
Eastern Mennonite College
Harrisonburg, Va. 22801
- Mr. Marshall S. White
11 Shawnee Trail
Blacksburg, Va. 24061
- Dr. Raymond R. White
Biology Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. Dexter Whitehead, Jr.
Physics Dept.
University of Virginia
Charlottesville, Va. 22901
- Ms. Mary Candace Whitehurst
1307 W. Little Creek Rd. 4 A
Norfolk, Va. 23505
- Miss Shirley K. Whitt
Lynchburg College
Lynchburg, Va. 24503
- Mrs. Lucille E. Whyburn
Mathematics Dept.
133 Bollinwood Road
Charlottesville, Va. 22903
- Dr. M. C. Wicht, Jr.
P. O. Box E
Emory, Va. 24327
- James E. Wickham, Jr.
109 Beverly Road
Ashland, Va. 23005
- Mr. Thomas F. Wieboldt
Box 53
Woodville, Va. 22749
- Prof. Walter W. Wierwillie
142 Whittemore Hall
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Ralph C. Wiggins, Jr.
Dept. of Psychology, V.C.U.
810 W. Franklin St.
Richmond, Va. 23235
- Dr. James P. Wightman
Chemistry Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Richard T. Wilfong
Box 372
Livingston, Va. 22942
- Mr. Gerald P. Wilkes
Route 1, Box 35
North Garden, Va. 22959

- Mr. Joseph B. Will
Agricultural Chem. Specialist
Southern States
627 E. Main
Richmond, Va. 23219
- Dr. H. T. Williams, Jr.
Physics Dept.
Washington and Lee Univ.
Lexington, Va. 24450
- Dr. R. L. Williams
Chemistry Dept.
Norfolk, Va. 23508
- T. G. Williamson
Nuclear Eng. Dept.
University of Virginia
Charlottesville, Va. 22903
- Lloyd L. Willis
Rt. 6, Box 1 A
Piedmont Va. Com. College
Charlottesville, Va. 22901
- Prof. G. B. Wills
Chemical Eng. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Wirt Wills
Plant Pathology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. H. G. F. Wilsdorf
Materials Science Dept.
Thornton Hall
University of Virginia
Charlottesville, Va. 22903
- Dr. Ben B. Wilson
Box 331
Virginia State University
Petersburg, Va. 23803
- Dr. Ernest Wilson
Box 291
Virginia State University
Petersburg, Va. 23803
- Mr. R. T. Wilson
Chemistry Dept.
Virginia Military Institute
Lexington, Va. 24450
- Mrs. James W. Wiltshire, Jr.
201 Woodland Road
Lynchburg, Va. 24503
- Dr. R. Lowell Wine
Rt. 11, Box 671
Roanoke, Va. 24019
- Dr. E. Burwell Wingfield
Biology Dept.
Virginia Military Institute
Lexington, Va. 24450
- Mr. Alfred L. Wingo
5909 Shrubbery Hill Road
Richmond, Va. 23227
- Miss Janet Winstead
Biology Dept.
James Madison University
Harrisonburg, Va. 22807
- Dr. Benjamin Winsten
522 Rogers Ave.
Hampton, Va. 23364
- Prof. Rolf G. Winter
Physics Dept.
College of William and Mary
Williamsburg, Va. 23185
- Dr. Lawrence J. Winters
Chemistry Dept.
Academic Division
Va. Commonwealth University
Richmond, Va. 23284
- Gene Wise
302 Letcher Ave.
Lexington, Va. 24450
- Dr. Milton B. Wise
College of Agr. & L.S.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mr. Lawrence L. Wiseman
College of William & Mary
Williamsburg, Va. 23185
- Dr. Lawrence A. Wishner
Chemistry Dept.
Mary Washington College
Fredericksburg, Va. 22402
- Dr. E. L. Wisman
Poultry Science Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. Jame F. Wolfe
Chemistry Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Dr. L. Wolfinbarger, Jr.
Biological Sciences Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. John H. Wood
School of Pharmacy
Medical College of Va.
Richmond, Va. 23298
- Dr. Lauren Woods
Box 606
M.C.V. Station
Richmond, Va. 23298
- William S. Woolcott
Box 248
University of Richmond
Richmond, Va. 23173
- James E. Worsham, Jr.
Box 27
University of Richmond
Richmond, Va. 23173
- Dr. J. W. Edward Wortham, Jr.
Biological Sciences Dept.
Old Dominion University
Norfolk, Va. 23508
- Dr. Eugene M. Wright
Vivarium—Jordan Bldg.
1300 Jefferson Park Ave.
Charlottesville, Va. 22908
- Dr. Theodore R. F. Wright
Biology Dept.
University of Virginia
Charlottesville, Va. 22903
- Ms. Martha M. Yeary
281 Stonewall Heights
Abingdon, Va. 24210
- Dr. Keith S. Yoder
Winchester Fruit Res. Lab.
2500 Valley Ave.
Winchester, Va. 22601
- Dr. W. Wh. Yongue, Jr.
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061
- Mrs. Edna Loving Young
125 Robertson Ave.
Danville, Va. 24541
- Philip R. Young
112 Lee Ave.
Poquoson, Va. 23362
- Dr. Robert S. Young
P. O. Box 7584
Charlottesville, Va. 22906
- Prof. Roderick W. Young
702 Airport Rd.
Blacksburg, Va. 24060
- James H. Yuan
Chemical Sciences Dept.
Old Dominion University
Norfolk, Va. 23598
- Mr. Joseph E. Zapotoczny
Route 2, Box 16
Waynesboro, Va. 22980
- James P. Zirk
Rt. 2, Box 98
Harrisonburg, Va. 22801
- Mr. Leon F. Zirkle
Box B-743
Martinsville, Va. 24112
- Dr. Paul L. Zubkoff
Dept. of Envir. Phys.
Va. Inst. of Marine Sci.
Gloucester Point, Va. 23062

STUDENT MEMBERS

Mr. James C. Adams, III
Plant Science Dept.
University of Delaware
Newark, De. 19711

Mr. Gordon C. Alling Jr.
211 15th St., S. W.
Charlottesville, Va. 22903

Ms. Loran D. Ambs
2214 Buchanan Drive
Baytown, Tx. 77520

Mr. Gary F. Anderson
Box 401
Virginia Inst. of Marine Sci.
Gloucester Point, Va. 23062

Mr. L. Scott Andrews
7602 Dunston Street
Springfield, Va. 22151

Mr. Paul J. Anninos
Inst. of Oceanography
Old Dominion University
Norfolk, Va. 23508

Robert K. Antibus
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Ms. Susan R. Arthur
385A Newcomb Street
Christiansburg, Va. 24073

Ms. Cynthia V. Bailey
1716 Clarkson Road, East
Richmond, Va. 23224

Miss Carol Ann Baker
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Richard Balandier
Bioch. & Nutr. Dept.
Michigan State University
East Lansing, Mi. 48823

Mr. Kenneth Banschick
108 Cresap Road
Charlottesville, Va. 22903

James A. Barron, III
Plant Path. & Physiol. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Dr. W. E. Beal
Animal Science Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Kirk H. Beattie
2505 Maple Drive
Plover, WI 54467

Doris Binkley
Statistics Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Katherine A. Booker
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Aura L. Bowling
2116 Fort Rice Street
Petersburg, Va. 23803

Ms. Felicia M. Boyd
5512 Hill Gail Road
Virginia Beach, Va. 23462

Mr. S. P. Briggs
Entomology Dept.
Price Hall, V.P.I. & S.U.
Blacksburg, Va. 24061

Ms. Ruth A. Brogan
518 Windsor Gate Road
Virginia Beach, Va. 23452

Edwin Brown, III
14208 Randall Drive
Woodbridge, Va. 22191

Mr. Gregory P. Brummett
6801 Brisbane St.
Springfield, Va. 22152

Ms. Linda E. Bush
10 S. Boulevard Apt. 10
Richmond, Va. 23220

Mr. David F. Calabotta
Route 4, Box 287
Christiansburg, Va. 24073

Mr. Edward L. Carmines
5232-F Castlewood Road
Richmond, Va. 23234

Mr. Jeffrey L. Carter
1711 Willow Avenue
Chesapeake, Va. 23325

Mr. Daniel J. Carucci
Major Lockwood Road
Pound Ridge, NY 10576

Carol W. Christman
Anatomy Dept.
Box 906
M.C.V. Station
Richmond, Va. 23298

Ms. Ramona E. Cintron
Box 3138
College Station
Fredericksburg, Va. 22401

David Lee Cochran
1208 Bridle Lane
Richmond, Va. 23229

Mr. David Alan Compton
4102 Meadow Green Court
Richmond, Va. 23229

Mr. H. Van T. Cotter
PLPP Dept.
Price Hall, V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Joseph W. Cross
515 Birmingham Ave. Apt. 5
Norfolk, Va. 23505

Mr. Lee Dalton
722 E. Roanoke St., #8
Blacksburg, Va. 24060

Mr. Lawrence E. Datnoff
Plant Path. & Physiol. Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Debra E. Davis
P. O. Box 1133
Tappahannock, Va. 22560

Mr. Franklin D. Davis
Route 2, Box 246
Beaverdam, Va. 23015

Mr. Jack D. Ruiter
121 N. Laburnam Ave., Apt. 2
Richmond, Va. 23223

Mr. Patrick F. Dowd
302 E. Jackson Street
Blacksburg, Va. 24060

Tamsey Warren Ellis
P. O. Box 125
Cape Charles, Va. 23310

Mr. R. Michael Ewing
Biological Sciences Dept.
Old Dominion University
Norfolk, Va. 23508

Ms. Mary Catherine Floyd
100 Somers Avenue
Moorestown, NJ 08057

Mr. Jerry L. Garner
302 Toms Creek Road
Blacksburg, Va. 24060

Mr. J. Shermer Garrison
2900 Princess Anne Crescent
Chesapeake, Va. 23321

Robert Wayne Grabb
5390 Kingswell Drive
Norfolk, Va. 23502

Ms. Lorraine S. Graney
1013 Draper Road
Blacksburg, Va. 24060

Mr. William A. Griffin
3725 Beacon Lane
Virginia Beach, Va. 23452

Miss Deborah Grossman
821 S Copeley IV
Charlottesville, Va. 22904

Mr. Stephen R. Halenda
3023-C Chamberlayne Avenue
Richmond, Va. 23227

Mr. G. B. Hall
Botany & Plant Path. Dept.
Bessey Hall
Ames, IA 50010

Mr. Paul B. Haney
Math Science Dept.
Thornton Hall
University of Virginia
Charlottesville, Va. 22901

Mr. Curtis Hinton
245 Cypress Circle
Portsmouth, Va. 23701

John L. Horst
1110 N. Dogwood Drive
Harrisonburg, Va. 22801

Mr. G. Dean Howell
1801 Holland Road
Suffolk, Va. 23434

Mr. John Hubbard
804 Pepper Avenue
Richmond, Va. 23226

Mr. Yer Van Hui
Statistics Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mrs. Barbara Israel
833-B Nevada Oval PAFB
Plattsburg, NY 12901

Mr. Michael J. Iwanik
Box 709
M.C.V. Station
Richmond, Va. 23298

Mr. Robert L. Jesse
608 W. 24th Street
Richmond, Va. 23225

Mr. Richard R. Johnson
1737 Don Lee Drive
Blacksburg, Va. 24060

Ms. Margaret E. Jones
2228 N. Harrison St.
Arlington, Va. 22205

Yoonok Kang
300 Allegheny St. S.E., Apt. 8
Blacksburg, Va. 24060

Ms. Carol P. Karnas
5820 Newtown Arch. Apt. 203
Virginia Beach, Va. 23462

Mr. Clifford B. Keil
515 Progress St.
Blacksburg, Va. 24060

Mr. Ronald J. Kendall
149 Cheatham Hall
V.P.I. & S.U.
Blacksburg, Va. 24061

Ms. Yeshirareg Kifle
Box 21
Ettrick, Va. 23803

Mr. Frederick W. Kunzinger, Jr.
404 Wolfs Neck Trail
Virginia Beach, Va. 23452

Yuk Miu Lam
Statistics Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Richard W. Lane
Pharmacology Dept.
Box 613
M.C.V. Station
Richmond, Va. 23298
A. Thomas Leggett, Jr.
5249 Rolleston Dr.
Virginia Beach, Va. 23462

Mr. Tom Leighton
2612 N. Fillmore St.
Arlington, Va. 22207

Mr. Kim Leong Lim
Human Nutrition & Foods Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Ms. Donna L. Lombardo
53 Knollwood Drive
Livingston, NJ 07039

Mr. Gary Wayne Long
121 Sherwood Drive
Williamsburg, Va. 23185

Steven B. Lorett
Terrace View Apts. 607
Blacksburg, Va. 24060

Ms. Lorraine Michelle Los
Entomology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Lt. George M. Lucas
Box 2135
1539 Coral Ridge Road
Roanoke, Va. 24018

Ms. Mary Q. Lund
1599-B McVeigh Road
Lynchburg, Va. 24502

Bruce W. MacLeod
9624 5th Bay St.
Norfolk, Va. 23518

Ms. Julie E. Maconaughey
9001 Patterson Avenue
Richmond, Va. 23229

Ms. Bonnie D. Mangus
307 Grafton District Road
Yorktown, Va. 23692

Ms. Cynthia A. Manshack
Route 8, Box 780
Monroe, NC 28110

Ms. Robin A. Mathews
524-B Edgewood Lane
Blacksburg, Va. 24060

Mr. Tom D. Mays
Route 1, Box 4A
Cartersville, Va. 23023

Joseph P. McCaffrey
Entomology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Gerald E. Meier
8513 Ivy Bridge Ct.
Springfield, Va. 22152

William H. Miele
Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Eric J. Miller
5721 Colter Court
Virginia Beach, Va. 23462

James W. Miller
2340 Petton Dr., Apt. 7
Charlottesville, Va. 22901

Mr. Joseph R. Morgan
Box 278
Burkeville, Va. 23922

Mr. Steven G. Mullins
4404 Kenwood Drive
Huntsville, Ala. 35810

Mr. Brian R. Murphy
Fish & Wildlife Science Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Michael W. Nath
313 New Street
Norfolk, Va. 23503

William E. Nietzold
J 1 Apartment Heights
Blacksburg, Va. 24060

Robert P. Olson
333 Briar Field Dr.
Chesapeake, Va. 23320

Mr. Steve A. Orndorff
9484 Farewell Rd.
Columbia, Mo. 21045

Ms. Laura R. Ostrander
241 Colonnade Drive
Charlottesville, Va. 22901

Pamela Kay Painter
7507 Pennington Road
Norfolk, Va. 23505

Michael P. Parrella
Entomology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24060

Sharon Patterson
1434 Blackwood Dr.
Salem, Va. 24153

Mr. John T. Patton
209A Giles Road
Blacksburg, Va. 24060

Mr. Richard P. Phipps

Microbiology Dept.
M.C.V. Station
Richmond, Va. 23298

Mr. Ronnie M. Pierce

228 Savona
Goleta, Calif. 93017

Ms. Adriene Y. Principe

1851 Duke of York Quay
Virginia Beach, Va. 23454

Mr. Venkat B. Rao

Dutch Village, #BB-5
Blacksburg, Va. 24060

Mr. James W. Rawls, Jr.

5001 Cary St. Road
Richmond, Va. 23226

Ms. Maura Reilly

Virginia State University
Petersburg, Va. 23803

Ms. Patricia L. Rice

Microbiology Dept.
Box 847
Medical College of Va.
Richmond, Va. 23298

Ms. Lisa A. Rossbacher

Geol. & Geophys. Sci. Dept.
13745 E. Via Del Palma 27
Whittier, Calif. 90602

Ms. Deborah J. Rowe

Entomology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Ms. Sharon Ryan

4724 Skipjack Court
Virginia Beach, Va. 23462

Mr. Ronald S. Salisbury

913 East Oak Street
Palmyra, Pa. 17078

Sherrie L. Sawyer

209 Delaware Ave.
Norfolk, Va. 23504

Mr. Don Schwab

RD 1, Box 147
Basking Ridge, NJ 07920

Ms. Linda E. Scott

640 Sequoia St. #2
Charleston, SC 29407

Mr. J. G. Scrivener

12913 Silver Crest
Chester, Va. 23831

Mr. Shannon C. Shafer

7655 Sprengle Court
Richmond, Va. 23228

Ms. Phyllis Shelton

3308 Prince William Drive
Fairfax, Va. 22031

Mr. Joseph Yoa-Cheng Shen

5353 Roslyn Road
Norfolk, Va. 23502

Ms. Virginia T. Shepherd

733 Holbein Place
Richmond, Va. 23225

Mr. Glen S. Simon

3204 Bute Lane
Richmond, Va. 23221

Ms. Sheila F. Smith

Geophysical Science Dept.
Old Dominion University
Norfolk, Va. 23508

Mrs. Debra Roop Smrcek

3316 King William Drive
Olney, Md. 20832

Mr. William G. Sproat, Jr.

182 Laurel Way Apt. 1-A
Herndon, Va. 22070

Laura Stein

Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Ms. Susan V. Stevens

Health Science Division
Box 581 - MCV VCU
Richmond, Va. 23298

Ms. Christine C. Tangney

Route 1, Box 231-A
Harding Road
Blacksburg, Va. 24060

Mr. Terrell A. Thomson

6009 Clover Lane
Richmond, Va. 23228

Mr. Michael H. Tickle

1403 Barriedale Road, Apt. C
Richmond, Va. 23225

Ms. Ada A. Townsend

200D, Park Apts.
Harrisonburg, Va. 22801

Mr. John Trumble

Entomology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. Michael R. Van Brunt

1336 Gunnell Ct.
McLean, Va. 22102

Alvin D. Vaughn

532 Moran Ave.
Salem, Va. 24153

Mr. Gregory M. Vogel

Biology Dept.
College of William and Mary
Williamsburg, Va. 23185

Ms. Susanna L. Von Oettingen

Biology Dept.
College of William and Mary
Williamsburg, Va. 23185

Ms. Kathleen Waddie

414 N. Sheppard St. #9
Richmond, Va. 23221

Ms. Kathleen A. Walker

P. O. Box 5482
Richmond, Va. 23220

Mr. Kenneth W. Waller

6610 St. George Road
Richmond, Va. 23234

Mr. Paul J. Wantuck

333 Four Season Drive
Charlottesville, Va. 22901

Mr. Scott C. Weaver

411 College Avenue
Ithaca, NY 14850

Mr. L. Bruce Weekley

Physiology Dept.
Box 551
Medical College of Virginia
Richmond, Va. 23298

Ms. Lisa Ann Weiss

Box 349-Frankford Farm
Berryville, Va. 22611

James A. Wesson

1655 Linden Drive
Madison, Wi. 53709

Mr. Robert A. Wharton, Jr.

Biology Dept.
V.P.I. & S.U.
Blacksburg, Va. 24061

Mr. J. Michael Williams

Roanoke College
P. O. Box 1046
Salem, Va. 24153

Mr. James H. Wilson

505 Yconas Dr.
Vienna, Va. 22180

Mr. Terry Woodworth

517 Rossmore Road
Richmond, Va. 23225

Mr. Huan-Ter Wu

41-68, 75th Street, Apt. 1
Elmhurst, NY 11373

NOTES

The world of biology at your fingertips!

Biological Materials



Carolina's New 1979-80 Catalog of Biological Materials

gives you easy access to thousands of
interesting and innovative top-quality
teaching materials.

Request your free copy today!

Carolina Biological Supply Co.

2700 York Rd.
Burlington, North Carolina 27215

Please send me a free 1979-80
Carolina Catalog 50.

Name _____

Institution _____

Address _____

City _____

State _____

Zip _____

Carolina Biological Supply Company

2700 York Road
Burlington, North Carolina 27215

Box 7
Gladstone, Oregon 97027

VIRGINIA JOURNAL OF SCIENCE

VOL. 31, NOS. 1 & 2
SPRING & SUMMER 1980

505.73
V81

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware
Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer
Box 637
Lancaster, Va. 22503

SECTION EDITORS

Agricultural Sciences

R. J. Stipes
417A Price Hall
VPI & SU
Blacksburg, Va. 24061

Physics

Dr. W. Peter Trower
Dept. of Physics
VPI & SU
Blacksburg, Va. 24061

Biology

Patrick F. Scanlon
Dept. of Fisheries & Wildlife
VPI & SU
Blacksburg, Va. 24061

Botany

David A. Breil
Dept. of Natural Sciences
Longwood College
Farmville, Va. 23901

Chemistry

Robert G. Bass
Dept. of Chemistry
Va. Commonwealth Univ.
Richmond, Va. 23284

Education

C. Dillard Haley
Dept. of Education
900 Fairfax St.
Radford, Va. 24141

Engineering

Walter R. Hibbard
301 Holden Hall
VPI & SU
Blacksburg, Va. 24061

Environmental Sciences

Michael Garstang
Dept. of Env. Science
Univ. of Virginia
Charlottesville, Va. 22904

Geology

Roddy V. Amenta
Dept. of Geology
James Madison Univ.
Harrisonburg, Va. 22801

Materials Science

John C. Duke, Jr.
Dept. of Eng. Sci. & Mechanics
VPI & SU
Blacksburg, Va. 24061

Medical Sciences

Charles O'Neill
Dept. of Biophysics
MCV
Richmond, Va. 23298

Microbiology

Paul V. Phipps, Jr.
Dept. of Microbiology
MCV-VCU
Richmond, Va. 23298

Psychology

Frank S. Murray
Psychology Dept.
Randolph-Macon Women's
College
Lynchburg, Va. 24503

Space Science & Technology

Sam S. Fisher
Dept. of Mechanical and
Aero-Space Engineering
Thornton Hall, Univ. of Va.
Charlottesville, Va. 22901

Statistics

J. Van Bowen, Jr.
Dept. of Mathematics
Univ. of Richmond
Richmond, Va. 23172

©Copyright, 1980 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P. O. 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia and additional entry at Harrisonburg, Virginia 22801. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1980: \$15.00 per year, U.S.A.; \$20.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$4.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send address changes to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper (8½ × 11 inches). Margins should be not less than 1½ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and affiliation, and proposed running title, all appear-

ing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first and last page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. Metamorphic Textures. Pergamon Press, New York. 350 pp.

Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians, Part III. Vertebrates* (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

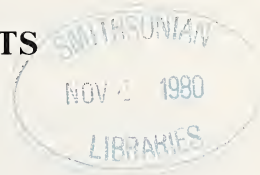
OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 31

Nos. 1 & 2

Spring and Summer 1980

TABLE OF CONTENTS



EDITORIAL

ARTICLES

- History of the Statistics Section. *Boyd Harshbarger*, VPI & SU. 3
- Seasonal Distribution of Rotifers in Lake Maury, Newport News, Virginia. *Paul N. Turner*, Christopher Newport College. 5
- The Intestinal Flora of *Notropis cerasinus*. *J. Henry Hershey and Gary A. Clarke*, Roanoke College. 9
- Regarding the Validity of the Endpoint Response of the ouse (McKenzie) Bioassay for Thyroid Stimulating Hormone. *Melvin Ching*, MCU-VCU. 13
- Contributions to the Reproductive Biology of the Eastern Pirateperch, *Aphredoderus sayanus*. *Edward O. Murdy and J. W. Edward Worthan, Jr.*, ODU. 20
- Upland Hardwood Forests of Pittsylvania Co., Virginia. *David A. Clark and Stewart Ware*, College of William and Mary. 28

BOOK REVIEW

- Humm on Virginia Marine Algae. *Joe Scott*, College of William and Mary 33

EDITORIAL

The publication of Volume 31, issues 1 and 2, Spring and Summer, in a single cover brings the Virginia Journal of Science back to a regular schedule. When we follow up this issue late in the year with the Proceedings 1980 issue, the Journal will have resumed regular quarterly publication. The editor wishes to express his great appreciation to the authors, reviewers, and Academy officials, all of whom have been appropriately patient, prompt, and supportive. Many of the headaches that would normally be an editor's have been borne by Business Manager Frank Kizer or former Academy President Dale Ulrich. Mr. Rick Kinkad, who handles the printing of the Journal at Good Printers, Inc. has provided this very green editor with extraordinary help and guidance. Thanks is also due the members and subscribers for their understanding for the delays during the transition of the Journal to a new editor and a new printer.

History of the Section of Statistics

Boyd Harshbarger

Professor Emeritus and Former Head
Department of Statistics
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

[Some of us tell our students that statistics is a field which was born during the second World War. The Statistics Section was born about the same time. With the watchful care of Dr. Harshbarger, it grew and became an important component of the Academy. His contribution, both to the Statistics Section and to the Academy, has been one of continued investment of time and leadership. Given his long involvement in the Statistics Section, Dr. Harshbarger was asked to provide this history of the section—Van Bowen, Statistics Editor.]

The Section of Statistics of the Virginia Academy of Science was proposed by Dr. Boyd Harshbarger, Professor of Statistics of the Virginia Polytechnic Institute, to Dr. E. C. L. Miller, Secretary-Treasurer of the Virginia Academy of Science, Medical College of Virginia, in December 1943. In the letter to Dr. Miller, he requested permission for a section of statistics in the Virginia Academy of Science at the Richmond Meetings, May 9-10, 1944. The permission for this meeting was granted, and Dr. Harshbarger immediately contacted Dr. G. P. Gray, Dean of the Medical College of Virginia, and asked him to serve as Chairman. Mr. J. A. Ewing of the State Department of Agriculture, Richmond, was asked to serve as Vice-Chairman and Dr. Boyd Harshbarger as Secretary. The latter immediately set about organizing a program for the May meeting. The first meeting consisted of 19 papers on applied statistics. The special attraction of the meeting was the invited talk by Miss Gertrude Cox, Director of the Institute of Statistics in North Carolina. Mr. Walter Hendrix of the Department of Economics and Dr. A. A. Pope of the U.S.D.A. Applied Industry also presented papers. This meeting of the section attracted a large audience of fifty people. Fifteen members of the Academy actually listed Statistics as their first choice during registration. Officers were elected for 1945 as follows: Chairman, Mr. J. A. Ewing, Crop Reporting Service, Richmond; Vice-Chairman, Dr. H. H. Zimmerley, Director of the Virginia Truck Experiment Station, Norfolk, (Dr. Zimmerley, who was a very influential member of the Academy and who was very much interested in Statistics, died before he could serve as Vice-Chairman.)

There was no formal meeting of the Virginia Academy of Science held during 1944-45, but in 1945-46 the Academy again met with Mr. J. A. Ewing as Chairman and Dr. Boyd Harshbarger as Secretary of the Section of Statistics. Two of the papers read at the

Section of Statistics were recommended by the Research Committee for the J. Shelton Horsley Award. One of these papers was by Dr. Boyd Harshbarger on, "Rectangular Lattices," and the other was by Dr. D. B. DeLeury on, "Estimation of Biological Populations." The awarding of this prize for highly meritorious original research to two separate papers set a precedent and helped to formalize the Statistics Section as a regular section of the Virginia Academy of Science. On May 11, 1946, the Statistics Section was formally recognized as a section of the Academy.

The Section of Statistics has had a full program since its inception. The program usually begins around 9:00 a.m. on Thursday and runs through to Friday noon or later. It has been the custom each year to bring in outstanding speakers to this section. Some of these distinguished speakers have been Dr. Harold Hotelling, University of North Carolina; Dr. W. A. Hendricks, U.S.D.A.; Dr. Clifford Maloney, Chemical Corps, U.S. Army; Dr. David Blackwell, University of California; Dr. Jack Youden, Bureau of Standards; Dr. Herbert Thom, U.S. Weather Bureau; Dr. H. O. Hartley, Texas A&M; Dr. Churchill Eisenhart, National Bureau of Standards.

It is interesting to note that Dr. D. B. DeLeury, one of the earlier members of this section, is now Dean of the Mathematics and Applied Mathematics Division of the University of Toronto. This is the largest Mathematics and Applied Mathematics Department in the world. Dr. DeLeury was not only a member of this section but was a winner of the J. Shelton Horsley Research Award.

The caliber of papers of this section is best shown by the number of times members of this section have won the J. Shelton Horsley Research Award. In 1951 it was won by Dr. D. B. Duncan with his paper, "A Significance Test for Differences between ranked Treatments on an Analysis of Variance and on the Properties of the Multiple Comparisons Test"; in 1956 by Mr. M. C. K. Tweedie with his paper, "Statistical Properties of Inverse Gaussian Distributions"; in 1956-57 by Dr. D. E. W. Schumann and Dr. R. A. Bradley with, "Comparison of the Sensitivities of Similar Experiments: Part I. Theory, Part II. Applications"; and in 1972 by Dr. I. J. Good and Dr. R. A. Gaskins with, "Global Nonparametric Estimation of Probability Densities."

Dr. Boyd Harshbarger was elected President-Elect of the Virginia Academy of Science in 1948 and Presi-

dent in 1949. In this capacity he served on the Council from 1949 through 1953. He founded the Virginia Journal of Science new series and served as its Editor-in-Chief from 1950-55. Before beginning the Journal he personally solicited donations amounting to \$1,500.00 and when he relinquished the successful Journal in 1955, he left a balance in excess of \$5,500.00.

Dr. Ralph A. Bradley was elected to the Council of the Virginia Academy of Science in 1958.

The members of the Section have served on numerous committees and have served as Chairmen of a number of very important committees of the Academy.

The chairman of the Section include many outstanding men in the field of statistics. How many of them do you know as authors, innovators or outstanding scholars?

1943-44	1955-56	1967-68
G. P. Gray	M. C. K. Tweedie	Valiant Mah
1944-45	1956-57	1968-69
No meeting	John E. Freund	I. J. Good

1945-46	1957-58	1969-70
J. A. Ewing	N. L. Enrick	R. Lowell Wine
1946-47	1958-59	1970-71
Rutledge Vining	John C. Griswold	George C. Canavos
1947-48	1959-60	1971-72
Rutledge Vining	Ira A. DeArmon, Jr.	R. H. Myers
1948-49	1960-61	1972-73
Boyd Harshbarger	James Armstrong	R. G. Krutchkoff
1949-50	1961-62	1974-74
W. A. Hendricks	Elizabeth Angle	W. H. Carter, Jr.
Charles M. Mottley	1962-63	1974-75
1951-52	Ronald Walpole	Janet Campbell
J. W. Youden	1963-64	1975-76
1952-53	Ronald Walpole	John E. White
A. M. Myster	1964-65	1976-77
1953-54	Virginia Perry	Leland E. Traywick
W. S. Connor	1965-66	1977-78
1954-55	Whitfield Cobb	Jesse C. Arnold
W. S. Connor	1966-67	1978-79
	S. J. Kilpatrick	Elbert G. Miller

Seasonal Distribution of Rotifers in Lake Maury, Newport News, Virginia

Paul N. Turner

16618 E. 13th Avenue
Aurora, Colo. 80010

Abstract—Rotifers are among the most abundant fauna found in fresh water lakes, ponds and pools, exceeded only by protozoans. In Lake Maury, Va., the relationships between rotifer genera present and time of year is marked. Which rotifers were present were clearly related to changing parameters of temperature and pH in a one year study. A species list of rotifers known to occur in Lake Maury is included. Examinations of this lake are continuing and further data will be made at a later date.

Introduction

Rotifers are among the most abundant fauna found in fresh water lakes, ponds and pools, exceeded only by protozoans. Essentially cosmopolitan, rotifers offer a unique experience to the microscopist, for their exotic shapes can intrigue even the most experienced limnologists. The environmental variables affecting distributions of rotifers have been reviewed by many authors, including Miracle (1977), Carlin (1943), Chengalath and Fernando (1973), Fairchild, Stemberger, Epskamp and Debaugh (1977), Hutchinson (1967), Stemberger (1974). This paper is an attempt to examine the limnetic and littoral rotifers in a small fresh water in southern Virginia, Lake Maury, and the relationship between the presence of various rotifers and two measured environmental parameters, water temperature and pH. Dissolved oxygen, photoperiods, population dynamics, predation and chemical availability were not measured. The only other work on rotifers of Virginia is the one by Harring (1913), which lists the rotifers of Washington and vicinity.

Study Area

Lake Maury is an artificial lake in southeast Virginia, located near the mouth of the James River (Fig. 1). The lake is located within Newport News city limits, and is surrounded by the wooded grounds of the Mariner's Museum. Lake Maury is fed by runoff streams from the surrounding rural areas. The Mariner's Museum staff can regulate the level of the lake by controlling the outflow to the James, and can therefore maintain, to some extent, the Lake's stability.

Materials and Methods

Samples were taken several times a month at one or more of the 17 sites from February 1978 to January 1979. Quart jars, pre-rinsed with lake water, were used for collecting at each of the sample sites. All samples were taken from shore areas. When present, available water plants were included in the sample jars. During

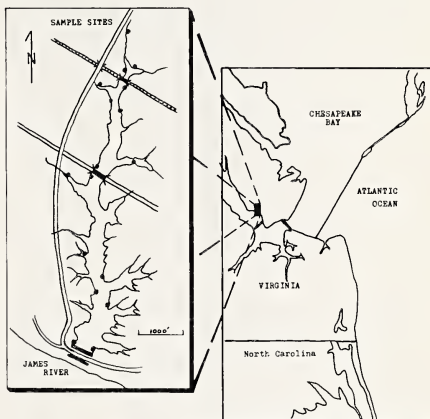


FIG. 1—Mouth of Chesapeake Bay with Inset Showing Location of Lake Maury and Sample Sites.

regular sampling, submerged water plants were used to fill $\frac{1}{2}$ the sample jar, and the rest was filled with available sample water. Sampling was also done with a 150 μ plankton net. Approximately once a month at one of the sample sites (on a rotating basis) the plankton net was passed through the water and emptied into sample jars as many times as it took to fill the jars. Each time a sample was taken by either method, site number, date, time, air and water temperatures, and pH were recorded for each site. Hydron wide range papers, pH 1-12, provided a rough indication of the pH. In the lab, sample jars were opened and placed to one side of an intense light. After an hour or so, the meniscus on the bright side of the jar contained most of the free swimming life in the jar, including the rotifers. The area was pipetted into a watchglass for low power examination. Small fragments of water plants were also included in the watchglass to insure that the examination process be as complete as possible. Further investigations were carried out at powers high enough for precise identifications. Neo-Synephrine was used for narcotising the rotifers, and when fixed, Flemmings fluid or 10% formalin was used. Due to the sampling technique, rotifers of the order Bdelloidea were not fully represented. Bdelloids prefer the benthos and mosses to the open waters examined.

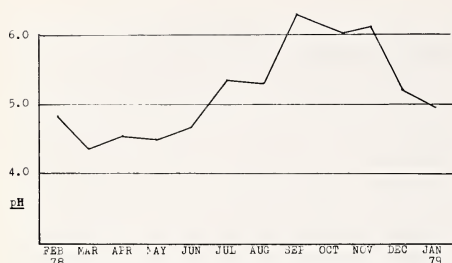


FIG. 2—Mean pH of Water Samples Collected Monthly.

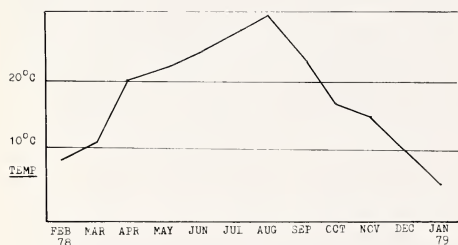


FIG. 3—Mean Temperature of Water Samples Collected Monthly.

Results

Both pH and temperature varied with the seasons, reaching highs in the late summer at pH 6.38 and 29.4° C. (Figure 2 & 3). Lowest pH's and temperatures were recorded in March and January.

Seasonal distributions for selected genera are illustrated in Table I. Genera such as *Lepadella*, *Trichocerca*, and *Notommata* were present most of the year, whereas *Brachionus*, *Platyias*, and *Scardium* were present only during summer months. *Lophocharis*, *Synchaeta* and *Trichotria* were found only in the winter and early spring months. Appendix I is a list of rotifers known to occur in Lake Maury. A total of 130 different species were found.

Discussion

The presence or absence of selected rotifer genera may be subject to many factors. The factors measured here were temperature and pH. *Brachionus*, *Platyias* and *Scardium* appeared in the month of June, when the pH was 4.6, and persisted until October, November and December when the lake water became less acidic (Figure 2, Table I). The temperature of the lake water during that time went from 22° C. to 17° C. (Figure 3). During October and November when these rotifers were disappearing, other genera such as *Lophocharis*, *Kellicottia* and *Synchaeta* appeared. These species were present in the water from the point that the lake

temperature dropped below 20.6° C. until the temperature rose above 20.6° C. (Figure 3, Table I). There were persistent species that remained active in the lake throughout most of the year: *Euchlanis*, *Lepadella*, *Trichocerca*, *Notommata*, *Lecane* and *Polyarthra*. Miracle (1977) suggests that these changes in rotifer populations may be due to an 'annual planktonic succession' rather than to arbitrary external stimuli.

Lake Maury is an example of a mildly acidic freshwater lake on the Virginia coastline. The list of rotifers should not be considered typical of all Virginian lakes due to the extreme climate variations found throughout the state. My examinations of Lake Maury are continuing and additional data on the effects of seasonal variables on rotifer populations will be published at a later date.

Acknowledgements

I would like to thank Dr. Ronald Mollick for his invaluable help in preparation of this manuscript for publication.

Lepadella
Trichocerca
Notommata
Lecane
Polyarthra
Euchlanis
Synchaeta
Lophocharis
Trichotria
Kellicottia
Asplanchna
Brachionus
Platyias
Mytilina
Scardium
Testudinella
Itura
Gastropus
Proaliniopsis
Filinia
Proales

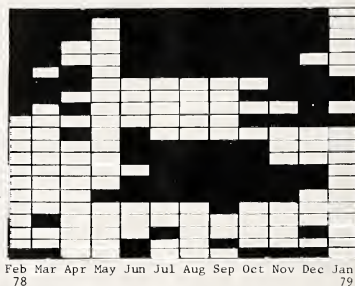


TABLE I—Monthly appearance of 21 selected rotifer genera found in Lake Maury. Presence of one or more representatives of the genus, not number of species or population size, is indicated by the blackened square for that month. Not many samples were taken in May.

List of Rotifer Species Found in Lake Maury, Va.¹

Phylum Nemanthelminthes, Class Rotatoria,
Subclass Eurotatoria
Superorder Digononta
Order Bdelloidea

Dissotrocha aculeata (Ehrenberg)
D. medioculeata (Janson)
Embata socialis Long
Macrotrachela decora (Bryce)
Philodina roseola Ehrenberg
P. megalotrocha Ehrenberg
P. brevipes (Murray)
Rotaria macrura Ehrenberg
R. neptunoidea Milne

¹Taxonomic classification follows Koste (1978).

Superorder Monogononta

Order Ploimida

Family Asplanchnidae

Asplanchna seiboldi Leydig

A. brightwellii Gosse

Family Brachionidae

Brachionus quadridentatus Herman

B. budapestinensis Daday

B. angularis Gosse

Keratella cochlearis cochlearis Gosse

K. cochlearis angulifera (Lauterborn)

K. cochlearis micracantha (Lauterborn)

K. cochlearis tecta (Lauterborn)

K. hispida pustulata (Müller)

K. crassa Ahlstrom

Kellicottia bostoniensis (Rousselet)

Platylabus quadricornis (Ehrenberg)

Family Colurellidae

Colurella uncinata deflexa (Ehrenberg)

C. oxycauda oxycauda (Carlin)

C. colurus compressa (Lucks)

C. obtusa obtusa (Gosse)

Lepadella acuminata (Ehrenberg)

L. imbricata Harring

L. similis (Lucks)

L. cryphaea Harring

L. triptera Ehrenberg

L. patella (Müller)

Lophocharis hutchinsoni Edmondson

L. oxysternon (Gosse)

L. salpina Ehrenberg

Squatinella mutica (Ehrenberg)

Family Dicranophoridae

Dicranophorus epicharis Harring-Myers

D. caudatus Harring-Myers

Encentrum spatiatum (Wulfert)

E. saundersiae Harring-Myers

Family Euchlanidae

Beauchampiella eudactylosum
(de Beauchamp)
Euchlanis callista Myers

E. calpidia Myers

E. deflexa (Gosse)

E. dilatata Ehrenberg

E. meneta Myers

E. triquetra Ehrenberg

Family Gastropodidae

Gastropus hytopus (Ehrenberg)

Family Lecanidae

Lecane luna (Müller)

L. luna presumpta Ahlstrom

L. sverigis Ahlstrom

L. ludwigii (Eckstein)

L. stokesii (Pell)

L. leontina (Turner)

L. unguolata (Gosse)

L. sibina Harring

L. (Monostyla) quadridentata Ehrenberg

L. (M.) closteroerca Schmarda

L. (M.) hamata Stokes

L. (M.) cornuta (Müller)

L. (M.) lunarias (Ehrenberg)

L. (M.) decipiens Murray

L. (M.) arcuata Bryce

L. (M.) scutata Harring-Myers

L. (M.) styrax Harring-Myers

Family Mytilinidae

Mytilina ventralis macrocantha
(Ehrenberg)

Family Notommatidae, Subfamily

Notommatinae

Cephalodella gibba (Ehrenberg)

C. racuna Myers

C. plicata Myers

C. mucosa (Myers)

C. doryphora Myers

C. catellina (Müller)

C. ventripes (Dixon-Nutall)

C. forficata (Ehrenberg)

Itura myersi Wulfert

I. viridis (Stenroos)

Monommata phoxa Myers

M. caudata Myers

M. diaphora Myers

M. appendiculata Stenroos

M. viridis Myers

Notommata pseudocerverus
de Beauchamp
N. pachyura (Gosse)

N. copeus Ehrenberg

N. cyrtopus Gosse

N. triptus Ehrenberg

Pleurotrocha petromyzon Ehrenberg

P. vernalis Wulfert

Taphrocampa selenura (Gosse)

T. anulosa (Gosse)

Family Proalidae

Proales sordida fallaciosa Gosse

P. gigantea Glasscott

P. palummeka Myers

P. cognita Myers

Proalinopsis selene Myers

Family Synchaetidae

Polyarthra dolichoptera (Idelson)

P. prolaba Wulfert

P. major (Burckhardt)

P. minor (Voight)

P. euryptera (Wierzejske)

P. remata (Skorikov)

Synchaeta littoralis Rousselet

S. pectinata Ehrenberg

S. tremula (Müller)

S. curvata Lie-Petersen

Family Trichocercidae

Trichocerca cavia (Gosse)

T. vernalis (Haurc)

T. tenuior (Gosse)

T. similis Wierzejski

T. tigris (Müller)

T. weberi (Jennings)

T. stylatus (Gosse)

T. bicuspes (Pell)

- T. carinatus* (Lamarck)
- T. elongata* (Gosse)
- Family Trichotridae
 - Trichotria pocillum* (Müller)
 - T. tetractis* (Ehrenberg)
- Order Gnesiotrocha, Suborder Floscularicea
 - Family Testudinellidae
 - Testudinella patina* (Hermann)
 - T. intermedia* (Gosse)
 - T. aspis* (Nilsen)
 - T. incisa* (Ternetz)
 - Family Conochilidae
 - Conochilus hippocrepis* (Schränk)
 - C. dossuarius* (Hudson)
 - Family Filiniidae
 - Filinia limnetica* (Zacharias)
- Suborder Collothecadea
 - Family Collothecidae
 - Collotheca coronetta coronetta* (Cubitt)
 - C. ornata ornata* (Ehrenberg)
 - C. hoodii* (Hudson)
 - C. paradoxa* Weber
 - Family Flosculariidae
 - Ptygura intermedia* Davis

References

- Carlin, B. 1943. Die Planktonrotatorien des Motalaström. *Medd. Lunds Univ. Limn. Inst.*, 5:1-255.
- Chengalath, R. and C. H. Fernando. 1973. The Planktonic Rotifera of Ontario with Records of Distribution and Notes on Some Morphological Variation. *Canad. Field-Nat.* 87:267-277.
- Fairchild, G., R. Stemberger, L. Epskamp and H. Debaugh. 1977. Environmental Variables Affecting Small-Scale Distributions of Five Rotifer Species in Lancaster Lake, Michigan. *Int. Revue ges. Hydrobiol.* 62:511-521.
- Harring, H. K. 1913. A List of the Rotatoria of Washington and Vicinity, With Description of a New Genus and Ten New Species. *Proc. U.S. Nat. Mus.*, 46:387-405.
- Hutchinson, G. E. 1967. A Treatise on Limnology, vol. 2. New York, Wiley.
- Koste, W. 1978. Die Radertiere Mitteleuropas begründet von Max Voight. 2 vol. Gebrüder Borntraeger, Berlin, Stuttgart.
- Miracle, M. R. 1977. Migration, Patchiness, and Distribution in Time and Space of Planktonic Rotifers. *Arch. Hydrobiol. Beih.* 8:19-37.
- Stemberger, R. 1974. Temporal and Spatial Distributions of Planktonic Rotifers in Milwaukee Harbor and Adjacent Lake Michigan. *Proc. 17th Conf. Great Lakes Res.* 120-134.

The Intestinal Flora of *Notropis cerasinus*

J. Henry Hershey and Gary A. Clarke

Department of Biology
Roanoke College
Salem, Virginia 24153

Abstract—A study of the intestinal flora of the crescent shiner, *Notropis cerasinus*, entailed aseptic excision of the intestine, isolation, and identification of the specific bacterial flora. Six fish were immediately examined following collection and five after a seven day starvation. The number of bacteria appearing on the culture plates obtained from starved specimens were significantly less than those obtained from non-starved specimens. This indicated that the intestinal bacterial flora of *N. cerasinus* was determined by its recent intake of food and the degree of contamination of the ingested food and water. In all, 29 bacterial strains were isolated, and of this number, 11 genera and 19 species were identified.

Introduction

Notropis cerasinus, the crescent shiner (family Cyprinidae), is common in the upper Roanoke and Kanawha River drainages of Virginia and West Virginia. Stanger (1959) has shown its principal foods to be chironomids constituting over 50% of the analyzed stomach contents), stimuliids, trichopterans, and coleopterans. A preference for chironomids suggests that *N. cerasinus* is a riffle-bottom feeder in the Roanoke River. Stanger's is the only published study of this species other than those concerning distribution.

General opinion today (Margolis, 1953; Mattheis, 1964) holds that there are no common bacterial commensals in the intestines of fish, and that the presence of bacterial flora depends solely upon the recent intake of food and the degree of contamination of the food and water. Since there has been no previous research on the intestinal flora of *N. cerasinus*, this report documents the qualitative composition of the intestinal flora of *N. cerasinus*, and tests the effect of recent food intake on that intestinal flora.

Methods

Eleven crescent shiners were used in this study. They were collected in the Roanoke River, 5 miles west of Salem near Glenvar on February 20 and March 5, 1978 with a 15' x 4' x 3/16" seine.

Six of the fish were examined for intestinal bacteria immediately following collection. Five of the fish were starved in aerated containers for seven days prior to making cultures of the intestinal contents.

The fish were opened aseptically after swabbing the external surface of the fish with 95% ethanol. Using sterile scissors, the abdomens were opened down the midline from the pectoral fins to very near the anus, with two transverse incisions being made to allow easy access to the intestine. The intestine, distal to the stomach, was then excised, placed into a sterile petri dish

using sterile forceps, and measured. The intestine was slit and divided into 3 segments from anterior to posterior. Samples of the intestinal contents were obtained from each section by inserting a sterile bacteriological needle through the intestinal segment to remove the intestinal contents. The intestinal contents were then aseptically streaked onto nutrient agar, EMB agar, and blood agar plates with a sterile bacteriological wire loop. Then, the intestinal segments were mashed and aseptically streaked onto nutrient agar, EMB agar, and blood agar. This inoculation procedure insured transfer of any bacterial types that were attached to the intestinal villi. The inoculated plates were incubated aerobically at room temperature ($23 \pm 3^\circ\text{C}$) for up to two weeks until enough growth for transfer to other media was found to be present.

Individual colonies were aseptically transferred from the original streak plates to new media (nutrient agar and blood agar slants) in order to isolate pure cultures. These cultures were incubated aerobically at $23 \pm 3^\circ\text{C}$. The loop-dilution and pour plating technique (Seeley and VanDemark, 1972) were used as a means of isolating individual bacterial species from the mixed cultures. Gram stains were performed on all 14-18 hour cultures of organisms to verify the purity of the culture obtained. The following stains were used when appropriate in addition to the Gram stain: Schaeffer and Fulton Endospore stain (for Gram-positive organisms), the Capsule stain, and Sudan black B stain (to demonstrate poly-B-hydroxybutyric acid deposits in bacteria). The agar shake culture in yeast-extract/tryptone agar was used as an index of the oxygen requirements of the microorganisms.

Observations were recorded as to growth of bacterial colonies, general appearance of individual colonies, and colony characteristics. Measurements of length and width were performed on stained bacteria using a Leitz Wetzlar screw micrometer eyepiece calibrated with a Bausch and Lomb stage micrometer.

After the organisms had been isolated, the following media and biochemical tests were prepared and used to identify the micro-organisms. (All materials and media were autoclaved at 15 lb/in.² for 15 minutes at 121°C):

- 1) glucose, sucrose, lactose, maltose, xylose, arabinose, and mannitol broth with methyl red indicator and inverted Durham tubes to detect acid and gas formation from carbohydrate breakdown,
- 2) 4% peptone broth and Nessler's reagent to detect deamination of amino acids,
- 3) 1% tryptone broth and Kovac's solution to detect indole production,

- 4) urea broth in the urease test to determine the hydrolysis of urea,
- 5) malonate broth to test for malonate utilization,
- 6) gluconate broth and Benedict's reagent to test for gluconate oxidation,
- 7) arginine broth and Nessler's reagent to test for arginine hydrolysis,
- 8) nutrient broth to observe growth characteristics in the broth,
- 9) litmus milk for observation of fermentation, proteolysis, and reduction (Seeley and VanDenark, 1972),
- 10) starch agar plates to detect the diastatic (starch-hydrolyzing) action of the organisms,
- 11) skim milk agar to detect casein hydrolysis,
- 12) nutrient gelatin to test for gelatin hydrolysis,
- 13) 0.75% nutrient agar deeps to determine motility,
- 14) lead acetate agar stab cultures to detect H_2S production,
- 15) yeast-extract agar slopes, nutrient broth, and 3% H_2O_2 for determination of catalase activity,
- 16) Methyl Red-Voges Proskauer (MRVP) medium, alpha naphthol solution (5% solution in alcohol), 40% KOH solution containing 9.3% creatine to test for acetyl/methylcarbinol and acid production,
- 17) nutrient-agar plates and p-aminodimethylaniline for the oxidase test, demonstrating the presence of cytochrome c,
- 18) citrate medium and KCN medium to determine the presence/absence of growth,
- 19) nutrient agar slopes to observe growth on agar slopes and cultural characteristics such as pigment formation.

Table I. Identifying Characteristics of 19 Bacterial Strains from the Gut of Freshly Caught *N. cerasinus*.

Key to tests in Table I:

a = diffusable yellow water-soluble pigment produced
 b = non-diffusable yellow pigment produced
 c = determined using a UV lamp
 d = surface violet ring from pellicle
 e = dull, wrinkled pellicle
 t = turbid
 +t = very turbid

s = sediment
 +s = heavy sediment
 p = pellicle
 A = acid production
 G = gas production
 () = slowly
 7 = in seven days
 0 = no growth
 pr. = proteolysis
 alk. = alkaline
 red. = reduction
 + = variable
 * = with green metallic sheen

Isolate #	Glucose	Lactose	Sucrose	Maltose	Xylose	Arabinose	Mannitol	4% Peptone	Litmus milk	Gelatin	Methyl red	Voges Proskauer ⁺	1% Tryptone	Nutrient broth	Malonate	Gluconate	H_2S	Starch Hyd.	Casein Hyd.	Arginine Hyd.	Oxidase	Catalase	Urease	Motility	EMB	Citrate	KCN	Length (cm)	Width (cm)	Gram Stain
1.	A	-	-	-	-	-	-	+	pr	+	-	-	-	t	-	-	-	+	+	+	+	-	-	+	+	-	-	1.6	0.7	-
2.	A	-	-	-	A	A	A	0	-	-	-	-	-	t	-	-	-	+	-	+	-	-	+	+	-	-	-	3.4	0.6	+
3.	-	0	0	0	0	0	0	+	alk	-	-	-	-	+t	-	-	-	-	-	+	-	-	+	+	-	-	-	2.1	0.4	-
4.	A	-	-	-	-	-	-	+	pr	+	-	-	-	t	-	-	-	+	+	+	+	-	+	+	-	-	-	2.3	0.7	-
5.	A	0	0	0	0	0	0	+	alk	-	-	-	-	+t	-	-	-	+	-	+	+	-	+	+	-	-	-	1.5	0.5	-
6.	A	-	-	0	0	0	0	+	alk	+	-	-	-	tp	-	-	-	+	+	+	+	-	+	+	-	-	-	2.8	0.8	-
7.	A	0	0	0	0	0	0	+	alk	+	-	-	-	tp	-	-	-	-b	+	+	+	-	+	+	-	-	-	1.2	0.6	-
8.	A	-	-	-	-	-	-	+	0	-	-	-	-	tp	-	-	-	-b	+	+	+	-	+	+	-	-	-	1.8	0.7	-
9.	A	0	0	0	0	0	0	+	0	+	-	-	-	tp	-	-	-	-b	+	+	+	-	+	+	-	-	-	1.3	0.8	-
10.	A	0	-	0	-	-	-	-	alk	-	-	-	+	t	-	-	-	-	-	-	+	+	+	+	-	-	-	1.9	1.2	-
11.	A	0	0	0	0	0	0	+	alk	+	-	-	-	t	-	-	-	-	+	+	+	-	+	+	-	-	-	2.1	0.6	-
12.	A(C)	A(C)	A(C)	A(C)	-	-	-	+	pr	+	+	+	-	ts	+	+	+	+	+	-	-	+	+	+	+	-	-	1.5	0.8	-
13.	AG	AG	AG	AG	-	-	-	+	red (+)	-	+	-	+	tps	+	+	+	+	+	+	-	+	+	+	+	+	+	2.5	0.9	-
14.	AG	AG	AG	AG	-	-	-	+	pr	+	-	-	+	tps	-	-	+	+	+	+	+	-	+	+	-	-	-	2.3	1.1	-
15.	AG	AG	AG	AG	-	-	-	+	red	+	-	+	+	tps	-	-	+	+	+	+	-	+	+	+	-	-	-	2.1	0.5	-
16.	AG	AG	AG	AG	-	-	-	+	alk	+	+	0	+	ts	-	-	+	+	+	+	-	+	+	+	+	-	-	2.2	0.6	-
17.	A	-	-	A	-	-	-	0	+	7	-	-	+	p ^d	-	-	-	+	+	+	+	-	+	+	-	-	-	2.8	0.9	-
18.	G	AG	AG	AG	-	-	-	-	-	-	+	-	+	t+s	-	-	-	-	-	-	-	+	+	+	+	+	+	2.1	0.5	-
19.	-	-	-	-	-	-	-	+	red	+	-	+	-	p ^e	-	-	-	+	+	+	-	+	+	+	-	-	-	1.7	0.8	+

(Table I continued)

Other Observations

Isolate #	Organism
1. diffusable fluorescent pigments ^c ; obl. aerobic; short rods, singly & in prs.	<i>Pseudomonas</i> sp.
2. poor, thin growth on nutrient agar; fac. anaerobe; medium rods, singly & in prs.	<i>Bacillus circulans</i>
3. colonies opaque to white; aerobic; med. to short rods, singly & in short chains	<i>Alcaligenes eutrophus</i>
4. diffusable fluorescent pigments; aerobic; short rods, singly & in prs.	<i>Pseudomonas</i> sp.
5. colonies cream-white; aerobic; short, thin rods, mostly single	<i>Alcaligenes faecalis</i>
6. non-fluorescent pigment; aerobic; medium rods, singly & in short chains	<i>Pseudomonas</i> sp.
7. non-fluorescent pigment; aerobic; short rods, singly & in prs.	<i>Pseudomonas</i> sp.
8. non-fluorescent pigment; aerobic; med. to short rods, singly & in short chains	<i>Pseudomonas</i> sp.
9. no endospores; aerobic; short, thin rods, singly & in short chains	<i>Flavobacter rigense</i>
10. smooth, white to opaque colonies; no poly-β-hydroxybutyrate inclusions present; aerobic; short, plump rods, singly & in prs.	<i>Acinetobacter</i> sp.
11. opaque colonies; aerobic; short rods, singly & in chains	<i>Pseudomonas</i> sp.
12. white to opaque colonies; aerobic; med. to short bacilli, singly & in prs.	<i>Serratia marcescens</i>
13. opaque to white colonies; aerobic; medium rods, singly & in short chains	<i>Enterobacter cloacae</i>
14. smooth, round convex colonies; fac. anaerobe; medium rods, singly & in prs.	<i>Aeromonas punctata punctata</i>
15. cream-colored colonies; aerobic; swarming noted	<i>Proteus vulgaris</i>
16. cream-colored colonies; aerobic; swarming noted	<i>Proteus mirabilis</i>
17. smooth colonies; violet pigment; fac. anaerobe	<i>Chromobacter violaceum</i>
18. convex, glistening, entire, cream-white to grey colonies; fac. anaerobe; medium rods occurring singly & in prs.	<i>Escherichia coli</i>
19. round, opaque to white colonies; presence of endospores; aerobic; medium rods, singly & in chains	<i>Bacillus subtilis</i>

The media for the biochemical tests were aseptically inoculated with the specific microorganisms and incubated from 1-7 days (depending on the specific test) at 23±3°C. All tests were performed in duplicate. After results were obtained from the biochemical tests, the organisms were keyed out to genus and species according to Bergey (1974).

Results

Abundant bacterial growth was obtained on all plate cultures of the intestinal contents of the fish examined immediately following collection. In these fish, undigested food was found to be present in the intestine. Each plate contained between 150 and 440 colonies. Twenty-nine bacterial strains were isolated from the gut flora of the 6 freshly-caught *N. cerasinus*, and of this number, 19 species and 11 genera were identified on the basis of their morphological and physiological characteristics.

As is illustrated in Table I, isolates 18 and 5 occurred in 5 and 4 fish respectively; isolates 3, 9, and 12 occurred in 3 fish; isolates 4, 7, 19, 13, 14, 15, and 19 in 2 fish; and isolates 1, 2, 16, and 17 occurred in only one fish each.

Thus it can be seen that the intestinal flora was composed of a variety of species of both indigenous aquatic bacteria and those species which are not commonly associated with the aquatic environment, but

which may, under suitable conditions, multiply in water.

Cultures of the contents of the intestines of the five starved individuals also showed the presence of *Pseudomonas*. Each specimen contained only one species representing isolate numbers 1, 4, 6, 8, and 11. Also found were *Escherichia coli* (in 2 fish), and *Proteus mirabilis* (in one fish). As there was no food present in the gut, the samples consisted mainly of mucus, which was always present. The number of colonies appearing on the culture plates varied from 12 to 43.

Discussion

Though certain strains of *Escherichia coli* were frequently found in the intestines of *N. cerasinus*, it is assumed that the typical fecal types indigenous to homoiothermic animals did not belong to the normal flora of the fish. Their occurrence may indicate that the animals, before having been caught, were in sewage-contaminated water.

Mattheis (1964) isolated and identified 204 bacterial strains of the genera *Pseudomonas*, *Aeromonas*, *Escherichia*, *Aerobacter*, and *Paracolobactrum* from the guts of 24 rainbow trout, 7 river trout, and 13 carp. Our findings paralleled his results concerning genera and species.

Apparently the kind of food that *N. cerasinus* consumes has considerable influence on its intestinal flora.

After prolonged starvation, bacteria, although few in numbers and in species, could still be demonstrated in the empty intestine, although this was a comparatively small number of colonies in contrast to the number that appeared on the culture plates of similar samples taken from non-starved, actively feeding fish. Margolis (1953) reported similar findings concerning the number of the bacterial colonies obtained from the intestine of actively feeding versus non-feeding trout and bullheads. He concluded that bacteria do not usually persist in the intestine of fasting fish.

Obst (1919) observed that of 94 herring (*Clupeus harengus*) taken off the coast of Maine, with no visible food in the alimentary tract, only 13 had bacteria in the stomach or intestine. Gillespie (1898) noted that the guts of certain fishes were free from bacteria in the absence of food. Hunter (1920) found the stomachs and intestines of spawning salmon to be sterile. Those salmon returning to fresh water to spawn do not feed, hence the digestive tract is free from food. Blake (1935) examined 22 salmonid individuals in which there was apparently no food in the digestive tract. In 15 of these, either the intestine, stomach, or both were free from bacteria. Of the remaining seven fish, Blake believed that four had digested the last of their food very shortly before examination. Other authors found no bacteria at all in the empty intestines of various fish (Mattheis, 1964).

The intestinal bacterial flora of *N. cerasinus* is

apparently determined by the recent intake of food and the degree of contamination of the ingested food and water. Whether the isolated and identified bacteria are commensals, mutuals, or transients contributing to the breakdown of nutrients in the intestines of the minnows is not yet clear.

Literature Cited

- Blake, I. (1935): Some observations on the bacterial flora of the alimentary tract of certain Salmonidae. *Final Report of the Furunculosis Committee*, App. B, pp. 60-67.
- Buchanan, R. E. and Gibbons, N. E. (eds.). (1974): In *Bergey's Manual of Determinative Bacteriology*, 8th edn., pp. 217-278, 529-550, The Williams & Wilkins Company, Baltimore.
- Gillespie, A. L. Fishery Board of Scotland, Report for 1898, p. 23. (Complete reference in Obst, 1919).
- Hunter, A. C. (1920): Bacterial decomposition of salmon. *J. Bacteriol.* 5, 353-358.
- Margolis, Leo. (1953): The Effect of Fasting on the Bacterial Flora of Intestine of Fish. *J. Fish. Res. Bd. Can.*, 10(2), 1953, 62-63.
- Mattheis, T. (1964): Ökologie der Bakterien im Darm von Süßwassernutzfischen. *Z. Fischeri.* 12, 507-600.
- Obst, M. M. (1919): A bacteriologic study of sardines. *J. Infectious Diseases*, 24, 158-169.
- Seeley, Harry W. and VanDermark, Paul J. 1972. (*Microbes in Action: A Laboratory Manual of Microbiology*, 2nd edn., pp. 22-23, 96, W. H. Freeman and Company, San Francisco.
- Stagner, Marlyn. (1959): Age and growth in two Piedmont minnows, *Notropis cerasinus* and *Notropis albeolus*. 61 p., M. S. Thesis. Duke University.

Regarding the Validity of the Endpoint Response of the Mouse (McKenzie) Bioassay for Thyroid Stimulating Hormone

Melvin Ching

Department of Anatomy, Medical College of Virginia,
Virginia Commonwealth University
Richmond, Virginia 23298

Abstract—The release of radiolabelled thyroid hormone into the circulation in female Swiss-Webster mice has been used extensively as a bioassay for thyroid stimulating hormone (TSH). However, the specificity of several bioassays of pituitary hormones have been subject to question. Consequently, the validity of the assay endpoint for TSH in the mouse was re-evaluated with respect to the effect of luteinizing hormone (LH) whose chemical composition closely resembles that of TSH. Mice, prepared for bioassay of TSH received injections of purified LH or alpha or beta subunits of LH. Identical doses of LH and LH subunits were quantified by LH and TSH radioimmunoassays and the results compared with those obtained by the bioassay. Microgram quantities of LH and subunits of LH elicited appreciable responses in the TSH bioassay but produced only negligible effects in the TSH radioimmunoassay. The response of the TSH bioassay of LH and alpha or beta subunits of LH was 40-56% that obtained with LH radioimmunoassay. However, the pituitary concentrations obtained by TSH bioassay when compared with those obtained by radioimmunoassays for TSH, LH, or Growth Hormone (GH) paralleled closely the TSH radioimmunoassay data, although in terms of quantitative estimates, there was a 15-fold discrepancy between the TSH assays. Estimations of pituitary concentrations of LH lead to the conclusion that, at the doses normally employed, most crude rat pituitary extracts do not contain sufficient quantities of LH to alter significantly bioassayable (McKenzie) estimates of TSH.

Introduction

The secretion of radiolabelled hormone from the thyroid gland into the blood stream of the female Swiss-Webster mouse has been used extensively as an endpoint in a bioassay for thyroid stimulating hormone (TSH) (McKenzie, 1958, 1960; Bakke, 1965; van Rees, 1966; Sinha & Meites, 1966; Solomon & McKenzie, 1966). The advent of the radioimmunoassay has largely supplanted the various bioassays for the quantitation of TSH in pituitary or blood. However, the McKenzie bioassay for TSH still is being used in cases where information concerning biological activity is deemed necessary (Harada, *et al.*, 1979; Ochi, *et al.*, 1979; Rousset, *et al.*, 1977). Past studies have explored the mechanisms of this bioassay (Florsheim *et al.*, 1970) and examined the effect of TSH in plasma and pituitary extracts (Rerup & Melander, 1965; Hershman, 1970). However, a test of the specificity of this bioassay, particularly with respect to the effect of luteinizing hormone (LH) has not been performed. This is necessary since traces of LH are commonly associated with TSH prepared from pituitary extracts. Moreover, the primary structures of these two glycoprotein hormones are quite similar and it has been reported that their alpha and beta chain can combine

in vitro to form hybrid molecules which retain some TSH biological activity (Liao & Lierce, 1970; Pierce, 1971; Pierce *et al.*, 1971a.; Pierce *et al.*, 1971b; Cornell & Pierce, 1973). The present study, therefore, was conducted so as to determine the extent to which LH and its molecular subunits stimulate release of radiolabelled thyroid hormone into the circulation of the mouse. The responses obtained were compared to those of a specific and sensitive radioimmunoassay that utilized highly purified bovine TSH as the reference preparation and antiserum to bovine TSH (Reichlin, *et al.*, 1970).

Materials and Methods

Preparation of Hormone Solutions for Assay

The TSH contaminant was absorbed from an LH preparation (NIAMD rat LH S-1) with an antiserum to bovine TSH as previously described (Ching, 1974). Standard and test solutions of rat LH (NIAMD RP-1) and alpha and beta subunits of bovine LH (NICHHD, WRR-1 α /A and WRR-2 β /B) were prepared using phosphate buffered saline (PBS, 0.01 M PO₄ + 0.15 M NaCl), pH 7.5 as diluent. Concentrations of rat LH, ovine α LH and B LH were prepared for bioassay (20 ug/ml) and radioimmunoassay (50 ug/ml). Bovine TSH for use in the bioassay (NIAMD B6, 2.54 USP U/mg) and radioimmunoassay had a potency of 20-30 USP U/mg and was a gift from Dr. John Pierce. It was dissolved in a Na₂CO₃ solution, pH 10, then diluted 20-fold with saline so as to reduce the pH to 7.5.

Anterior lobes, obtained from rats 4 weeks after ovariectomy, between the 18th-20th day of gestation or after the first week of lactation, were weighed then homogenized individually in 1 ml of 0.05 M phosphate buffer, pH 7.5 containing 1% bovine serum albumin. Following refrigerated centrifugation at 1500 x g, the clear pituitary supernatants were stored at -20°C.

Preparation of Bioassay Recipients

The TSH and LH preparations and the subunits of ovine LH were tested for their effects on a bioassay for TSH (McKenzie, 1958, 1960) that utilized as recipients female Swiss-Webster mice weighing 13-15 g at onset. Pellets of a low iodine diet (Nutritional biochemicals Corporation (NBC), Cleveland, Ohio) and distilled water were provided *ad libitum*. After 10 days the mice

were each injected intraperitoneally (ip) with 3 μ ci 125 I followed 1 hour later with a subcutaneous (sc) injection (nuchal region) of 10 μ g of the sodium salt of l-thyroxine (T_4 , NBC). Two days later 10 μ g T_4 was again administered to maintain the suppression of endogenous TSH release. The following day the animals were used as bioassay recipients.

Bioassay Protocol

Five minutes before the removal of the first blood sample and injection of hormone or test substance, mice, serving as recipients in the TSH bioassay, were warmed under an incandescent lamp in order to dilate their tail veins. Animals were removed one by one from the warming chamber and 50 μ l blood obtained by puncture of a retro-ocular, sinus using a Drummond microcap pipet; the blood was diluted in 0.5 ml distilled water contained in a 10 x 75 mm disposable glass tube. The mouse was placed in a restraining chamber and 0.25 ml of saline, hormone or test solution injected into a tail vein. Hormone solutions were administered in a volume of 0.25 ml at doses depicted in Tables 1 and 4, whereas pituitary extracts were diluted with PBS so that the dose administered was 1/250 of the gland per 0.25 ml. The time that elapsed between the collection of the blood and the intravenous (iv) injection was 1 minute. After 2 hours a second sample of 50 μ l blood was removed from either the same or the opposite retro-ocular sinus. The release of radiolabelled thyroid hormone elicited by administration of the test sub-

stance was determined by measuring the increase in blood radioactivity which was then related to a standard curve and equivalence in bovine TSH estimated.

TSH, LH and GH Radioimmunoassays

Test doses of purified LH and LH subunits were quantified by radioimmunoassays for LH (Niswender *et al.*, 1968, 1969) and TSH (Reichlin *et al.*, 1970) to determine the extent to which they cross reacted with TSH antiserum. Radioimmunoassays were also employed to measure concentrations of TSH, LH and GH (Schalch & Reichlin, 1966) in crude pituitary extracts of Sprague Dawley female rats. The fraction of pituitary assayed per tube were as follows: TSH, 50 μ l of 1/100 anterior pituitary (AP); LH, 50 μ l of 1/150 AP; GH, 50 μ l of 1/4000 AP. These data were compared with quantitative estimates obtained by the TSH bioassay.

Results

Comparison of the TSH Bioassay and Radioimmunoassay

The release of radioactive thyroid hormone into the circulation of the mouse followed a characteristic rectilinear log-dose response to TSH. However, the vagary of the bioassay was evident when the index of inherent precision (λ) test (Cornfield, 1970) was applied (Table 1). The average λ for all doses was 0.227 which is within the limits of acceptability for bioassays.

TABLE 1

Bioassay standard curve for thyroid stimulating hormone (TSH) (NIAMD B6) expressed as increase in blood radioactivity per dose of TSH. The data represent the means \pm SD of 5 recipients at each point. The formula for the stepwise multiple regression line calculated by the method of least squares (Stanley, 1963) is $y = b + m \log x = 2749.0 + 1476.3 \log x$ where b is the intercept, m is the slope and x is the dose of TSH in mU. The inherent index precision (λ) = SD/ m (Cornfield, 1970). The average λ was 0.227.

Dose of TSH		Change in blood radioactivity (cpm)		y	λ
(ng)	(mU)	(mean \pm SD)			
0	0	-6 \pm	28	--	--
80	0.2	94 \pm	36	55.9	0.024
160	0.4	427 \pm	160	498.8	0.108
320	0.8	946 \pm	391	941.7	0.264
640	1.6	1440 \pm	437	1384.6	0.296
1280	3.2	1978 \pm	483	1827.5	0.444

TABLE 2

Radioimmunoassay standard curve for thyroid stimulating hormone (TSH) expressed as percent radiolabelled TSH bound to homologous antibody at varying concentrations of non-radiolabelled antigen; means of duplicate values in the % bound column. The reference preparation of bovine TSH from Dr. John Pierce had a bioassay potency (Chick thyroid p^{32} uptake) of 20-30 USP U/mg and the antibody to bovine TSH from Dr. Si Reichlin was used at a dilution of 1:15,000. $y = b + m \log x = 91.7 - 47.8 \log x$. The average λ of the valid portion of the curve was 0.045. See heading of Table 1 for additional information.

TSH (ng)	% Bound/Total (mean \pm SD)	y	λ
0	63.4 \pm 2.0	--	--
3.125	58.3 \pm 2.1	--	--
6.250	56.9 \pm 2.8	57.9	0.065
12.500	47.2 \pm 2.8	45.1	0.065
25.000	31.2 \pm 1.3	32.3	0.030
50.000	19.4 \pm 1.0	19.4	0.023

In the TSH radioimmunoassay, increasing log doses of nonradioactive TSH progressively displaced radioactive TSH tracer from the antibody binding sites (Table 2). In contrast to the bioassay, the λ at each dose was minute, the average λ being only 0.046 which is well within the range of acceptability. This measure of precision illustrates the superiority of a radioimmunoassay over a bioassay in terms of ability in measuring minute differences in hormone concentration. It should be noted also that the sensitivity of the TSH radioimmunoassay was 25 times that of the bioassay (Tables 1 and 2).

LH Radioimmunoassay

The precision and sensitivity of the radioimmunoassay was illustrated once more in the standard curve for LH (Table 3). The average inherent λ of all dose standards was 0.045 which is similar to that of the TSH radioimmunoassay.

Testing the Specificity of the TSH Bioassay

As might be expected, purified LH exhibited far greater binding affinity (83%) for LH antiserum than for the heterologous bovine TSH antiserum (Table 4). One-way analysis of variance (ANOVA) revealed considerably less α and β LH subunits bound to LH antiserum, precipitation was nevertheless still greater with this antiserum than with the heterologous antiserum to TSH ($p < 0.001$). In the latter case, LH or subunits of LH were either undetectable or barely detectable by TSH radioimmunoassay (Table 4). Para-

doxically, equivalent doses of LH or LH subunits evoked significant increased in blood radioactivity in the mouse ($p < 0.001$ for LH; $p < 0.05$ for α LH). However, LH and subunit LH activities when assessed by the mouse bioassay were 40%-56% of that assessed by LH radioimmunoassay and actual quantities of LH measured were different (Table 4).

Assay of Anterior Pituitary Extracts

Concentrations of TSH, LH and GH in pituitary extracts of intact, ovariectomized, pregnant and lactating rats were determined by bioassay and appropriate radioimmunoassays. Quantitative estimates from the bioassay were 15 times greater than that obtained from radioimmunoassay (Table 5). However, when evaluated from the standpoint of change from the intact normal condition, the values obtained by the 2 TSH assays more closely paralleled one another than those of the LH or GH assays (Table 5).

Discussion

The results of Table 4 suggests a dose of 5000 ng LH has the same effect as 1625 ng TSH in eliciting release of radiolabelled thyroid hormone in the mouse. This is not particularly surprising in view of the finding that TSH and LH molecules, of human and cattle, consist of 2 chemically similar polypeptide chains (Pierce, 1971; Pierce *et al.*, 1971b; Cornell & Pierce, 1973). Indeed biochemical studies suggest that the C1 or alpha chains of LH and TSH of cattle possess identical

TABLE 3

Radioimmunoassay standard curve for luteinizing hormone (LH) expressed as percent radiolabelled LH bound to homologous antibody at varying concentrations of non-radiolabelled LH reference preparation (NIAMD RP-1) $y = b + m \log x = 25.7 - 11.4 \log x$. The average λ of the steep rectilinear portion of the curve was 0.034. See heading of Table 1 for additional information. Means of duplicate values in the % bound column.

LH (ng)	% Bound/Total (mean \pm SD)	y	λ
0	27.0 \pm 1.4	--	--
1	24.3 \pm 0.2	--	--
2	22.5 \pm 0.1	22.3	0.008
4	19.0 \pm 0.5	18.9	0.043
8	15.2 \pm 0.2	15.5	0.017
16	12.0 \pm 1.4	12.1	0.122
32	8.0 \pm 0.1	8.6	0.008
64	4.8 \pm 0.1	5.2	0.008
128	3.8 \pm 0*	--	--

* SD < 0.05

amino acid sequence and 3-dimensional configurations (Pierce, 1971; Pierce et al., 1971a) and that the primary, secondary, and tertiary structures of the beta chains, while not identical, were similar (Pierce, 1971). It was not surprising, therefore, that restoration of bioassayable thyrotropin activity occurred when the beta chain of TSH was combined with the alpha chain of LH as compared with activity elicited by either polypeptide chain (Pierce, 1971; Pierce et al., 1971b). Thus, this introduced the possibility that, because of the close relationship of the chemical nature of LH and TSH, either glycoprotein hormone could be recognized by the other's biological receptors. Recent studies have demonstrated the presence of gonadotropic hormone alpha and beta subunits within pituitary extracts and sera and further that an LH preparation, free from TSH, stimulated the endpoint response of a bioassay for TSH (Hagen & McNeilly, 1975; Ching, 1974). The present study also suggests that microgram quantities of LH are able to elicit a significant endpoint response in the mouse thus demonstrating the non-specificity of this TSH bioassay (Table 4). Although FSH possesses a common alpha subunit with that of TSH and LH and a hormone-specific beta chain

(Pierce, 1971), the testing of rat FSH subunit cross reactivity was not included in this study simply because these materials were not readily available.

In view of this finding the more appropriate concern should be whether or not pituitary extracts, at dilutions normally employed in the McKenzie bioassay, contain sufficient concentrations of LH to stimulate enough secretion of radiolabelled thyroxine to impair the reliability of the bioassay. To answer this question, bioassay and radioimmunoassay were employed to quantitate TSH, LH and GH in the same crude pituitary extracts of female rats physiologically manipulated to bring about changes in pituitary contents of LH (Table 5). GH was included for study because, although it is chemically unlike TSH or LH, it is abundant in the pituitary gland and has been shown to possess some potentiating ability on another TSH bioassay whose endpoint is the thyroid gland's uptake of ^{131}I (Evans et al., 1958; Ching et al., 1975).

Calculations reveal, utilizing the data provided in Table 5, that the dose of LH administered to recipient mice would not exceed 200 ng LH even at the higher anterior lobe weights of 15 mg. According to Table 4, this dose of LH is not able to stimulate an endpoint

TABLE 4

Comparison of quantitative estimates by thyroid stimulating hormone (TSH) bioassay and TSH and luteinizing hormone (LH) radioimmunoassays of test doses of rat LH (NIAMD LH S-1) and ovine LH alpha and beta subunits (NICHHD WRR-1 α /A and WRR-1 β /B. Shown are the means \pm SD of 4-6 determinations per point. ND = nondetectable.

Dose (ng)	TSH Concentration (ng)		LH Concentration (ng)
	Bioassay	Radioimmunoassay	Radioimmunoassay
0	ND	ND	ND
450 LH	69 \pm 87	ND	--
750 LH	79 \pm 58	ND	--
5000 LH	1625 \pm 308	ND	4082 \pm 39
5000 α LH	81 \pm 59	3 \pm 1	144 \pm 104
5000 β LH	110 \pm 141	1 \pm 0*	273 \pm 122

SD < 0.05

TABLE 5

Concentration in nanograms per milligram wet weight of bioassayable thyroid stimulating hormone (TSH) and radioimmunoassayable TSH, luteinizing hormone (LH), and growth hormone (GH) in pituitary extracts of intact normal controls (NC), ovariectomized (O), pregnant (P) and lactating (L) Sprague-Dawley rats. Shown are the means \pm SD of 6 determinations per point. The percent of change from normal are shown within brackets.

Group	Bioassay TSH	TSH	Radioimmunoassay	
			LH	GH
NC	4100 \pm 3300 (100%)	300 \pm 100 (100%)	460 \pm 150 (100%)	7300 \pm 1300 (100%)
O	3600 \pm 1300 (88%)	240 \pm 30 (80%)	1770 \pm 880 (385%)	10700 \pm 1500 (146%)
P	2200 \pm 800 (54%)	150 \pm 20 (50%)	3250 \pm 1000* (706%)	8000 \pm 1300 (110%)
L	3600 \pm 1600 (88%)	80 \pm 10 (27%)	620 \pm 20 (134%)	2700 \pm 1200* (37%)

*p < 0.05 when compared to its NC value

response in the mouse with the exception of Group L, the close parallelism of the radioimmunoassay and bioassay of TSH in the same rat pituitaries, in which LH was quantified, lends support to the notion that the estimations of TSH concentrations by the McKenzie bioassay evidently were not altered by LH present in the pituitary extracts. Other investigators, employing radioimmunoassay (RIA) or bioassay (OAAD), also report concentrations of LH in pituitary that are too low to sufficiently stimulate the TSH bioassay. Calculations from data of Gay & Midgley (1969) reveal that no more than 172 ng LH (RIA male rat pituitaries) would be administered to mouse recipients. Similarly only 112 ng LH (OAAD) from proestrous rat pituitaries would be injected into mice (Bradshaw & Critchlow, 1966). Anderson & McShan's (1966) study show that a mere 128 ng LH (OAAD) would be administered, based on equivalent fractions of anterior pituitaries from ovariectomized rats; even smaller doses of LH would be obtained in other phases of the estrous cycle.

The experiments of Niswender *et al.*, (1968) show some pituitary concentrations of LH to be of sufficient intensity (20 ug - 64 ug, RIA or OAAD), even after a 250-fold dilution and theoretically would stimulate thyroidal release of thyroxine in the mouse. However, LH concentrations in rat sera (Niswender *et al.*, 1968) or ovine sera (Niswender *et al.*, 1969) are too minute (<90 ng/0.25 ml) to stimulate the TSH bioassay. Thus it appears that although some confusion exists as to whether or not pituitary concentrations of LH are sufficiently high to significantly alter true estimates of TSH when assayed in the radioiodinated-primed mouse, the majority of evidence suggest that the hormone levels are too low to be of much consequence. Certainly, this is true of the circulating levels of LH in rats and sheep. As Table 5 suggests, glandular changes in GH concentration do not appear to alter in obvious fashion the estimates of the TSH bioassay. However, interpretations of this kind are not without risk since crude pituitary extracts contain other hormones, any number of which could stimulate or inhibit the endpoint response of the McKenzie bioassay for TSH.

Although an attempt was made to minimize the stressing of the mice through undue restraint, surgery or warming, it is impossible to eliminate these insults entirely nor was it desirable to do so since stress of the recipients are an unavoidable part of the McKenzie bioassay. After all, this was an inquiry into the reliability of this bioassay's endpoint response to test substances which indeed is thought to be influenced by stress (Sowers, *et al.*, 1977; Sterling & Lazarus, 1977). There is ample evidence that short term immobilization, surgery, either anesthesia or other stresses decrease pituitary secretion of TSH in animals and man (Sowers *et al.*, 1977; DuRuisseau *et al.*, 1978; Sterling & Lazarus, 1977) as well as alter the secretion of GH and LH (Sowers *et al.*, 1977; DuRuisseau *et al.*, 1978; Krulich *et al.*, 1974; Schallch & Reichlin, 1966) which indirectly influence thyroid gland activity (Evans *et al.*,

1958; Ching, 1974; Ching *et al.*, 1975). However, the reduction of TSH secretion by the pituitary of the mouse recipient as a result of stress would be of little consequence in the McKenzie assay since supranormal doses of T_4 are administered in order to suppress endogenous TSH release. Rather, the more appropriate concern should be what modulatory effect stress has on thyroid activity. Sowers *et al.*, (1977) reported that serum T_3 titers were depressed in humans 10 minutes after surgery and presumably stress does suppress some thyroid hormone release in the mouse recipient in the McKenzie TSH bioassay. However, judging by the good correlation of radiolabelled thyroid hormones released into the blood in response to stepwise increments of administered TSH (Table 1) it would appear that the stresses to which the mice had been subjected, did not alter the endpoint of the assay sufficiently to compromise its veracity.

Acknowledgements

This work was supported by NIH Grant 1 R01 HD 10912, and by a grant from the Human Growth Foundation. The bovine TSH and reagents for the LH radioimmunoassay were gifts from NIAMD. The alpha and beta subunits of ovine LH were the gifts of NICHD. The highly purified bovine TSH was the gift of Dr. John G. Pierce of UCLA and Dr. Si Reichlin of the New England Medical Center, Boston, provided the antiserum to bovine TSH which was used in the TSH radioimmunoassay. The author thanks Paul Winkle for technical assistance when portions of this work were performed at the University of Rochester (NY).

References

- Anderson, R. R. & McShan, W. H. (1966) Luteinizing hormone levels in pig, cow and rat blood plasma during the estrous cycle. *Endocrinology* 78, 976-982.
- Bakke, J. L. (1965) Assay of human thyroid-stimulating hormone by 18 different assay laboratories using 12 different methods. *J. Clin. Endocr. Metab.* 25, 545-550.
- Bradshaw, M. & Critchlow, V. (1966) Pituitary concentration of luteinizing hormone in three types of "constant estrous" rats. *Endocrinology* 78, 1007-1014.
- Ching, M. (1974) A re-examination of the tadpole in metamorphic stasis as a recipient in a bioassay for thyroid-stimulating hormone. *J. Endocr.* 61, 15-19.
- Ching, M.C.H., Schallch, D.S. & Lebda, N.J.A. (1975) Role of growth hormone in the enhancement of the propylthiouracil-induced goitrogenesis by small doses of thyroxine. *Acta Endocr.* 79, 238-247.
- Cornell, J. S. & Pierce, J. G. (1973) The subunits of human pituitary thyroid-stimulating hormone. *J. Biol. Chem.* 248, 4327-4333.
- Cornfield, J. (1970) Inequality of variances and the index of precision. In: *Invalidity in Bioassays*, McArthur, J. W. & Colton, T., eds. MIT Press, Cambridge, Massachusetts pp. 145-162.
- DuRuisseau, P., Taché, Y., Brazeau, P. & Collu, R. (1978) Pattern of adenohipophyseal hormone changes induced by various stresses in female and male rats. *Neuroendocrinology* 27, 257-271.

- Evans, E. S., Simpson, M. E. & Evans, H. M. (1958) The role of growth hormone in calorigenesis and thyroid function. *Endocrinology* 63, 836-852.
- Florsheim, W. H., Williams, A. D. & Schönbaum, E. (1970) On the mechanism of the McKenzie bioassay. *Endocrinology* 87, 881-888.
- Gay, V. L. & Midgley, A. R. Jr. (1969) Response of the adult rat to orchidectomy and ovariectomy as determined by LH radioimmunoassay. *Endocrinology* 83, 1359-1364.
- Hagen, C. & McNeilly, A. S. (1975) Identification of human luteinizing hormone, follicle-stimulating hormone, luteinizing hormone β subunit and gonadotrophin α subunit in foetal and adult pituitary glands. *J. Endocr.* 67, 49-57.
- Harada, A., Hershman, J. M., Reed, A. W., Braunstein, G. D., Dignam, W. J., Derzko, C., Friedman, S., Jewelewicz, R. & Perkary, A. E. (1979) Comparison of thyroid stimulators and thyroid hormone concentrations in the sera of pregnant women. *J. Clin. Endocr. Metab.* 48, 793-797.
- Hershman, J. M. (1970) Different slopes of the dose-response curves of human and bovine TSH in the McKenzie bioassay. *Endocrinology* 86, 1004-1007.
- Krulich, L., Hefco, E., Illner, P. & Read, C. B. (1974) The effects of acute stress on the secretion of LH, FSH, prolactin and GH in the normal male rat, with comments on their statistical evaluation. *Neuroendocrinology* 16, 293-311.
- Liao, T.-H. & Pierce, J. G. (1970) The presence of a common type of subunit in bovine thyroid-stimulating and luteinizing hormones. *J. Biol. Chem.* 245, 3275-3281.
- McKenzie, J. M. (1958) The bioassay of thyrotropin in serum. *Endocrinology* 63, 372-382.
- McKenzie, J. M. (1960) Bioassay of thyrotropin in man. *Physiol. Rev.* 40, 398-414.
- Niswender, G. D., Midgley, A. R. Jr., Monroe, S. E. & Reichert, L. E. Jr. (1968) Radioimmunoassay for rat luteinizing hormone with antiovine LH serum and ovine LH- ^{131}I . *Proc. Soc. Exp. Biol. Med.* 138, 807-811.
- Niswender, G. D., Reichert, L. E. Jr., Midgley, A. R., Jr. & Nalbandov, A. V. (1969) Radioimmunoassay for bovine and ovine luteinizing hormone. *Endocrinology* 84, 1166-1173.
- Ochi, Y., Hashiya, T., Miyazaki, T., Kajita, Y. & Yoshimura, M. (1979) An attempt to analyze various thyroid stimulators by the receptor assay using hTSH radioimmunoassay. *Endocrinol. Japon.* 26, 1-7.
- Pierce, J. G. (1971) Eli Lilly lecture: The subunits of pituitary thyrotropin—their relationship to other glycoprotein hormones. *Endocrinology* 89, 1331-1344.
- Pierce, J. G., Liao, T.-H., Carlsen, R. B. & Reimo, T. (1971a) Comparisons between the α chain of bovine thyrotropin and the C1 chain of luteinizing hormone. *J. Biol. Chem.* 246, 866-872.
- Pierce, J. G., Liao, T.-H., Howard, S. M., Shome, B. & Cornell, J. S. (1971b) Studies on the structure of thyrotropin: its relationship to luteinizing hormone. *Rec. Progr. Hor. Res.* 27, 165-212.
- Reichlin, S., Martin, J. B., Boshans, R. L., Schalch, D. S., Pierce, J. G. & Bollinger, J. (1970) Measurement of TSH in plasma and pituitary of the rat by a radioimmunoassay utilizing bovine TSH: effect of thyroidectomy or thyroxine administration on plasma TSH levels. *Endocrinology* 87, 1022-1031.
- Rerup, C. & Melander, A. (1965) The bioassay of thyrotrophin in plasma. *Acta Endocr. (Kbh)* 50, 177-194.
- Rousset, B., Orgiazzi, J. & Mornex, R. (1977) Perchlorate ion enhances mouse thyroid responsiveness to thyrotropin, human chorionic gonadotropin and long acting thyroid stimulator. *Endocrinology* 100, 1628-1635.
- Schalch, D. S. & Reichlin, S. (1966) Plasma growth hormone concentration in the rat determined by radioimmunoassay: Influence of sex, pregnancy, lactation, anesthesia, hypophysectomy and extracellular pituitary transplants. *Endocrinology* 79, 275-280.
- Sinha, D. & Meites, J. (1966) Effects of thyroidectomy and thyroxine on hypothalamic concentration of "thyrotropin releasing factor" and pituitary content of thyrotropin in rats. *Neuroendocrinology* 1, 4-14.
- Solomon, S. H. & McKenzie, J. M. (1966) Release of thyrotropin by the rat pituitary gland *in vitro*. *Endocrinology* 78, 699-706.
- Sowers, J. R., Raj, R. P., Hershman, J. M., Carlson, H. E. & McCallum, R. W. (1977) The effect of stressful diagnostic studies and surgery on anterior pituitary hormone release in man. *Acta Endocr. (Kbh)* 86, 25-32.
- Stanley, J. (1963) The essence of biometry. McGill Univ. Press, Montreal. pp. 63-68.
- Sterling, K. & Lazarus, J. H. (1977) The thyroid and its control. In: *Ann Rev. Physiol.* 39, 349-371.
- van Rees, G. P. (1966) The effect of triiodothyronine and thyroxine on thyrotropin levels in the anterior pituitary gland and blood serum of thyroidectomized rats. *Acta Endocr. (Kbh)* 51, 619-624.

Contributions to the Reproductive Biology of the Eastern Pirateperch, *Aphredoderus sayanus*

Edward O. Murdy and J. W. Edward Wortham, Jr.

Department of Biological Sciences
Old Dominion University
Norfolk, Virginia 23508

Abstract—The reproductive system (including ovarian and testicular development) of *Aphredoderus sayanus* is described. The gonads of forty-three specimens (13 male; 29 female; one undetermined) were examined histologically and a gonosomatic index (GSI—the ratio of total gonad weight to total body weight) was calculated for each individual. Gonads began to ripen in the fall, with the testes maturing sooner than the ovaries. Sperm were seen in November males while mature eggs were not detected until April 1. *Aphredoderus sayanus* is a spring spawner.

Introduction

The Eastern Pirateperch, *Aphredoderus sayanus*, of the monotypic family Aphredoderidae, is an inhabitant of coastal drainage areas along the Atlantic seaboard; however, detailed information on the biology of this fish is scarce. The most recent work was done by Parker and Simco (1975), who described some basic activity patterns of *Aphredoderus*. Martin and Hubbs (1973) briefly described some aspects of embryological development in *Aphredoderus* and Mansueti (1963) detailed the migration of the vent and urogenital pore from its early developmental position, immediately anterior to the anal fin, to the jugular or thoracic position in the adult. This phenomenon has been well documented by numerous researchers (Jordan and Evermann, 1896; Forbes and Richardson, 1920; Hall and Jenkins, 1954).

Aphredoderus sayanus exhibits no external sexual dimorphism; and sex determination, except during the spawning season, must be done by gross examination of the gonads. No information exists in the literature concerning the histology of the reproductive system of the Aphredoderidae. This study was undertaken to describe the micro and macro-anatomy of the reproductive system and the seasonal histological changes in the gonads of *Aphredoderus sayanus*.

Materials and Methods

Specimens for histological examination were collected from Cypress Pond, a part of the Dismal Swamp drainage, located on Rte. 642 outside of Suffolk, Virginia. Collections were routinely made on a monthly basis, but in certain months two or three samples were taken. Specimens were kept alive and transported to the laboratory at Old Dominion University.

The majority of fish were captured by using a 1/2 inch mesh seine. A dip net was used with some success along the banks of small feeder streams where there was

heavy vegetation.

The overall body weight before the removal of the gonads was measured to the nearest 0.1 gm. Gonad weight was measured to the nearest 0.1 mg. The gonad weight was expressed as a percentage of the total body weight to give the gonosomatic index (GSI) (Wiebe, 1968).

All freshly killed specimens were weighed and the standard length measured to nearest millimeter. Ventral and lateral incisions were made through the body wall to form a flap which, when lifted, exposed the entire coelomic contents. The gonads were removed intact, weighed, and fixed.

Some tissues were fixed in 10% formalin; formal-fixed material was generally unsatisfactory since it exhibited a great degree of shrinkage (Ross, 1953). Most of the tissue was fixed in Bouin's fluid for 8 hours, dehydrated in an ethanol series, cleared in benzene and embedded in 56°C paraffin. A majority of the tissue sections were cut 8 μ m thick, but some sectioning was done at thicknesses of 6 and 10 μ m. In addition, sperm smears were made by smearing testicular material directly on albuminized slides that had a few drops of Ringer's solution added to them. This was followed by fixation in 95% ethanol for 24 hours.

Most sections were stained with Harris' hematoxylin and eosin Y, whereas some were stained with Milligan's Trichrome stain to differentiate muscle and connective tissue. Sperm smears were stained in Kernechtrot-Fast green (FCF).

For some of the more advanced stages of the female ovary, the blocked tissue was soaked in a mixture of glycerin and alcohol (Bowers and Holliday, 1961) which facilitated sectioning of the yolk-laden eggs.

Measurements of maturing ovarian and testicular structures (to nearest tenth of micrometer) were made with an ocular micrometer from the slides used for histological examination. In measuring ova, only the maximum diameter was considered.

Results

Structure of the ovaries—The ovaries, lying posterior to the stomach, are paired structures which are fused dorsally and posteriorly. The ovaries are attached medially by mesenteries to the air bladder, ventrally to the urogenital canal and posteriorly to the wall of the body cavity. An abundance of fat surrounding the ovaries was seen in the females taken in the early fall

and in those specimens collected in the spring which were assumed to have spawned (spent condition). Fat was not seen in specimens which had near-ripe or ripe gonads.

The oviducts of both ovaries combined to form a single duct which leads posteriorly to the ventral portion of the urinary bladder. The urinary bladder is a clear, thin-walled sac at the most ventral and posterior portion of the cavity. The urogenital canal courses ventrally from the bladder to run alongside the intestine with both structures ending in external openings in the thoracic region. Both the vent and the urogenital pore are situated jugularly in the adult, the vent being anterior to the pore.

The ovaries are covered with a thin sheet of mesothelium below which lies the ovarian wall, the tunica albuginea. The thickness of this connective tissue structure is extremely variable during the oogenic cycle. The tunica albuginea measured 25 μm in thickness just prior to spawning (March 18th specimen), while in the post-spawned condition (April 23rd specimen) it measured 275 μm . Variation in the thickness of the tunica albuginea around a single ovary was also noted. Internally, many connective tissue lamellae project inward from the tunica albuginea to the lumen of the ovary (Fig. 1).

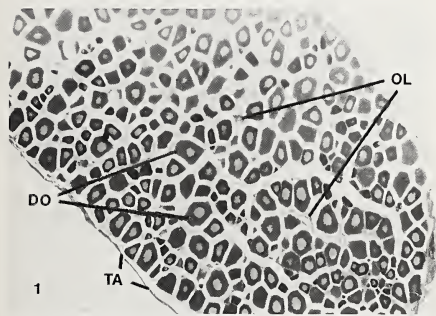


FIG. 1.—Cross-section of ovary of 74mm S.L. female collected September 4, 1976, showing very early stages of development. Hematoxylin-eosin, 240x. Formalin fixed.

The oogonia undergo periods of multiplication, growth and maturation. The transformation of an oogonium into an oocyte is accompanied by a general growth of both nucleus and cytoplasm. The smallest oocytes were found in a September specimen and had a cellular diameter of 55 μm and a nuclear diameter of 15 μm . Nucleoli were numerous and were noted at the periphery of the nucleus. As the follicle matured, the nucleus began to lose its circular shape, becoming more irregular in outline (Fig. 2). From this stage onward, the cytoplasm increases greatly while the nucleus grows very little.

Beginning with the October-November specimens,

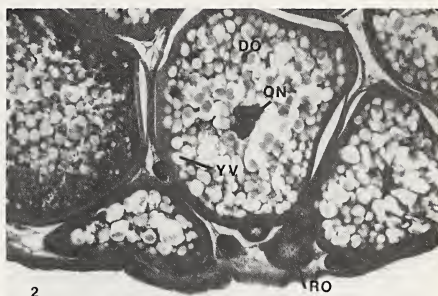


FIG. 2.—Cross-section near periphery of ovary of 69mm S.L. female collected November 29, 1976, showing yolk-filled oocyte. Hematoxylin-eosin, 100x. Bouin's fixative.

there were two distinct types of oocytes readily apparent in the ovary: the maturing oocyte which had a thin layer of follicular cells around it and the resting oocyte which did not have a follicular layer (Fig. 2). The resting oocytes grow no larger and remain at this stage throughout the rest of the ovarian cycle. In addition these resting oocytes showed no signs of degeneration and were typically more numerous than the maturing oocytes. The largest maturing oocyte at this time had a cellular diameter of 150 μm and nuclear diameter of 75 μm .

Vitellogenesis was first noted in an October specimen. Yolk deposition occurred first in the larger and more peripheral vesicles and, by November, these vesicles were noted in the region of the nucleus. Spatial sequence of yolk deposition has been cited by many researchers (James, 1946; Bowers and Holliday, 1961; Merret, 1970; Rizkalla, 1970). Outside the yolk vesicles the cytoplasm showed a number of empty vacuoles whose contents were probably dissolved during dehydration (Fig. 2).

The membranes surrounding the egg have been the subject of a great deal of controversy. Different researchers have used the terms zona pellucida, zona radiata, oolemma, chorion and vitelline membrane to describe the same structure. Ginzburg (1968) presented a strong argument in favor of the term zona radiata, which is adopted here.

Abbreviations on Plates

CL.	corpus luteum	SL.	seminiferous lobule
CT.	connective tissue	SM.	smooth muscle
DO.	developing oocyte	SP.	spermatids
FN.	follicular nucleus	SS.	secondary spermatocytes
IN.	interstitium	SY.	secondary yolk
OL.	ovigerous lamellae	SZ.	spermatooza
ON.	oocyte nucleus	TA.	tunica albuginea
PS.	primary spermatocytes	UNK.	unknown structure
RO.	resting oocyte	YV.	yolk vesicle
RSZ.	residual spermatooza	ZRI.	zona radiata (inner)
SG.	spermatogonium	ZRO.	zona radiata (outer)

The zona radiata makes its first appearance after the beginning of yolk formation. It directly adjoins the oocyte surface and contains radial striations (pore canals) that are clearly visible at high magnifications. At first there is only one zona radiata (inner zona radiata), but a second layer (outer zona radiata) is subsequently laid down (Fig. 3). Both layers thicken as development proceeds. In the December specimen the cellular diameter measured $525\text{ }\mu\text{m}$ with a nuclear diameter of $85\text{ }\mu\text{m}$. In this specimen an unidentified structure was seen in several areas of the ovary (Figs. 4 and 5). This structure was located between developing oocytes (Fig. 4) and consisted of a number of individual units. Upon examination at a higher magnification, each unit appeared to consist of a lumen surrounded by a stratified layer of smooth muscle-like cells, outside of which was a connective tissue covering. These units were oriented in various directions with no distinct pattern of organization. To the best of our knowledge, this structure bears no resemblance to any structure previously described in the literature (Turner, 1919; Foley, 1926; Craig-Bennett, 1930; Matthews, 1938; Weisel, 1943; James, 1946; Cooper, 1952; Gokhale, 1957; Beach, 1959; Bowers and Holliday, 1961; Stanley, Chieffi and Botte, 1965; Lambert and van Oordt, 1965; Ahsan, 1966; Moser, 1967; Merrett, 1970; Rizkalla, 1970; Bieniarz and Epler, 1976), and its functional significance is unknown. However, it could possibly be a baroreceptor functioning in the process of ovulation.

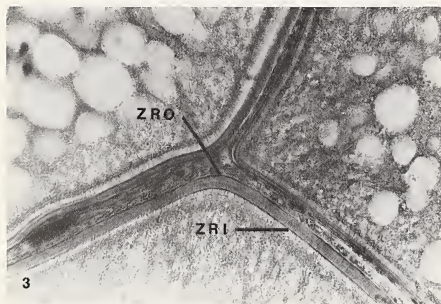


FIG. 3—Portions of three oocytes from a specimen collected December 13, 1976. Notice both the inner and outer zona radiata and also the follicular cell layer. Hematoxylin-eosin. 400x. Bouin's fixative.

There was a lack of specimens for both January and February, due to an inability to collect more than one pirateperch by seining. It has not been determined where the pirateperch dwell in the colder winter months. It was not until March 18, 1977 that another adult female was collected. This specimen (42 mm S.L.) had large yolk-filled oocytes that were still developing and, in general, her ovaries were not considerably different from the December females. The nuclei of

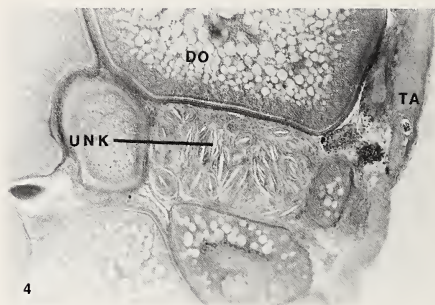


FIG. 4—Cross-section through the ovary of the specimen shown in Fig. 3. In the center is the unidentified structure which was found in several areas of this ovary and the ovary of a different specimen. Hematoxylin-eosin. 100x. Bouin's fixative.



FIG. 5—Enlargement of structure shown in Fig. 4. The ducts were composed of smooth muscle tissue and the fibers were collagenous. Milligan's trichrome stain. 200x. Bouin's fixative.

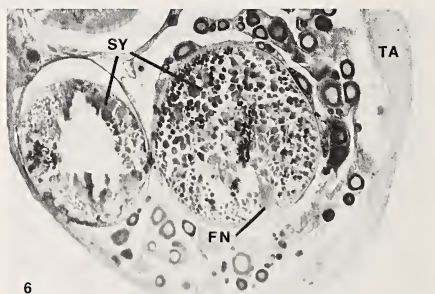


FIG. 6—A section through an ovary of a 60mm S.L. female collected April 1, 1977, showing large oocytes filled with the second yolk. The large follicle in the center measured 1mm in diameter. Hematoxylin-eosin. 40x. Bouin's fixative.

these oocytes were usually absent due to the great loss of follicular contents resulting from sectioning. The largest follicular diameter was 675 μm .

On April 1, 1977, a single adult female (60 mm S.L.) was collected whose ovaries were bright orange and contained large spherical eggs. The eggs had a dark orange center and a light orange cortex. The ovaries in this instance were extremely swollen, this enlargement being attributed to the growth of existing eggs. The eggs measured almost 1 mm in diameter (Fig. 6) and were found to contain an oil droplet approximately 0.3 mm in diameter, which agrees with the findings of Martin and Hubbs (1973). The yolk in these eggs stained differently from previous specimens, staining faintly reddish with eosin. A nucleus 150 μm in diameter was seen in one of these sectioned eggs (Fig. 6).

The next stage in the oogenic cycle, the spent ovary, was seen in the single adult specimen collected on April 13, 1977. The ruptured follicles of the spent ovary, which were once as big as the eggs, were collapsed and the follicular epithelium, which now represented the luteal-like cells, appeared thickened (Fig. 7). Most of these post-ovulatory follicles become transformed into corpora lutea-like structures resembling those previously reported in fishes. There was also a thickening of the tunica albuginea which now measured 275 μm at its thickest point. Also most of the residual (resting) oocytes were still present in the spent ovaries.

Structure of the testes—The testes occupy the same position as the ovaries and have a similar form. The testes, fused posteriorly, are connected by mesenteries to the surrounding viscera in much the same way as the ovaries. As development proceeds the testes enlarge and gradually fill the entire cavity. In one near-ripe male, one lobe of the testes spread almost to the pericardial region.

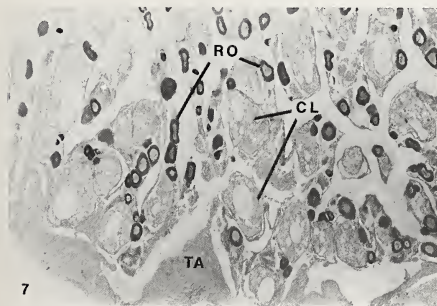


FIG. 7.—A section through the ovary of an April 30, 1977, female showing numerous resting oocytes and corpora lutea. Hematoxylin-eosin, 40x. Bouin's fixative.

Each testis, covered with a connective tissue sheath, is formed of closely packed seminiferous lobules (Fig. 8). The lobules of the testes of fish are not strictly

comparable with mammalian seminiferous tubules, as there is no permanent germinal epithelium in fish (Craig-Bennett, 1930). The germ cells are arranged in cysts within the lobules and each cyst behaves as a unit during maturation. Within any lobule germ cells in various stages of development can be found. The lobules are separated by the interstitium which consists of connective tissue, vascular elements, and interstitial cells.

The first male testis studied was from an early September specimen. The testes were two thin, clear strands that, when viewed microscopically, revealed nests of germ cells and the beginning of lobule formation (Fig. 8).

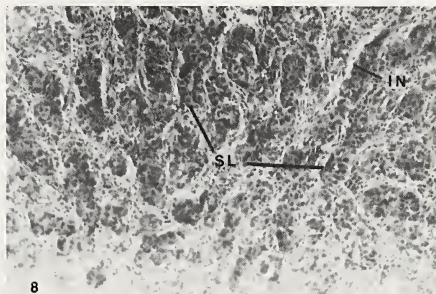


FIG. 8.—Cross-section of testis of a 79mm S.L. male collected September 4, 1976, showing very early stages of development. Hematoxylin-eosin, 200x. Formalin fixed.

The next male available for study was from a November specimen, and the lobules showed all stages of spermatogenesis, including tailed sperm (Fig. 9). In these sections, four types of spermatogenic cells were distinguishable. The largest of these were the spermatogonia, which had a clear outline and a prominent nucleus. This situation was first observed by Turner (1919) and has been noticed by many other researchers (Foley, 1926; Matthews, 1938; James, 1946; and Rizkalla, 1970).

The spermatogonia of *Aphredoderus* measures between 4.5–5.5 μm . The spermatogonial nuclei were very basophilic, while the cytoplasmic matrix stained faintly with Hematoxylin-eosin.

The commencement of maturation was recognized by the appearance of the primary spermatocytes, which where the most numerous cells in the lobules. They were rounded cells having indistinct outlines, with only the basophilic nuclei taking up the stain. The nuclei of these cells measured between 2.7–3.3 μm (Fig. 9).

The transition period from primary spermatocytes to secondary spermatocytes, as well as the time required for secondary spermatocyte division, must be very brief due to the paucity of clumps comprised wholly of

secondary spermatocytes. It is very difficult to determine with accuracy the difference between the late secondary spermatocyte stage and the early spermatid stage. However, the nuclei of the secondary spermatocytes were slightly smaller than that of the primary spermatocytes, measuring between 1.5-2.2 μm , while the spermatids were recognized by their overall small size (1.0-1.5 μm) and their deeply staining, concentrated chromatin material, which gave their nuclei a solid appearance (Fig. 9).

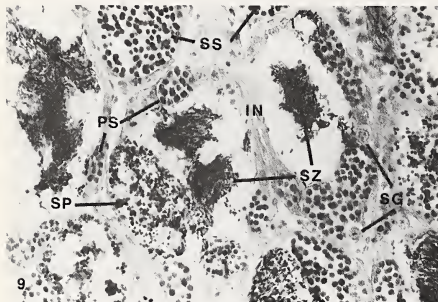


FIG. 9—Longitudinal section through the posterior portion of a testis from a 95mm S.L. male collected January 18, 1977, showing lobules densely packed with sperm. Hematoxylin-eosin. 100x. Bouin's fixative.

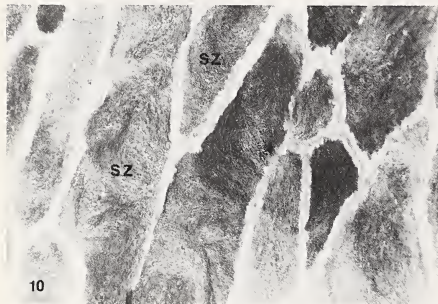


FIG. 10—Cross-section through the anterior portion of a testis from the same specimen as Fig. 9, showing all stages of spermatogenesis. Hematoxylin-eosin. 400x. Bouin's fixative. 6 μm section.

Isolated sperm could be viewed and measured from smears. The January sperm heads measured 5 μm in length with tails approximately 30 μm long. The heads tapered at the anterior end and became wider posteriorly.

At this stage the spermatozoa lay in the center of the lumen, and spermatids usually occurred in clumps around the sperm, but without clear serial arrange-

ment of cells in order of maturity. Bowers and Holliday (1961) noted a similar arrangement in the testes of the herring.

In the specimen taken in November, the lobules located more posteriorly were packed with sperm, while some of the more anterior lobules contained sperm not nearly so numerous. A specimen from December showed a decreasing number of lobules which were not packed with sperm. Many of these lobules did not contain spermatocytes or spermatids. Some of the most anterior lobules in this specimen were still lacking sperm.

In the January specimen there was a further increase in the number of lobules containing densely packed sperm (Fig. 10). Only a few of the most anterior lobules still contained spermatocytes. The abdomen in this specimen was extremely swollen, approximating spawning conditions.



FIG. 11—A section through the spent testis of an April 23, 1977, male showing residual sperm. Hematoxylin-eosin. 200x. Bouin's fixative.

The next male that was collected had already spawned, and his testes has assumed the post-spawn condition. This specimen was collected on April 13 and his testes had the appearance of two thin clear strands. These testes differed from the testes of the early September specimen in that the residual sperm had not been resorbed (Fig. 11). In subsequent collections on April 23, April 30 and May 13, no males had testes which contained any residual sperm. These testes differed from the testes of the early September specimen in that the residual sperm had not been resorbed (Fig. 11).

Discussion

The relationship of the gonads to other internal organs in *Aphredoderus* followed the typical pattern of other teleosts. The course of gametogenesis has not been described in detail for many teleosts. However, this process in *Aphredoderus* is similar, in general, to those descriptions available. There are, of course, a number of differences between the developmental pro-

Table I. Monthly collection data of specimens showing sex, standard length, total weight, gonad weight, gonosomatic index and average gonosomatic index.

Month	Sex	S.L. (mm)	Wt. (gr)	Gonad Wt. (gr)	GSI	Ave. GSI per collection
1976						
Oct. 16	F	50	2.9	0.05	0.02	
	F	50	8.4	0.03	0.00	0.01 F
Nov. 9	F	73	9.5	0.26	0.03	
	F	75	13.0	0.43	0.03	0.03 F
	M	72	10.4	0.85	0.08	0.08 M
Nov. 29	F	69	9.0	0.51	0.06	
	F	76	11.2	0.51	0.05	0.06 F
	M	83	17.6	1.83	0.10	0.10 M
Dec. 13	F	81	11.0	0.41	0.04	
	F	92	19.3	0.74	0.04	
	F	78	10.5	0.36	0.03	
	F	70	7.3	0.25	0.03	
	F	44	1.6	0.05	0.03	0.04 F
	M	39	1.2	0.01	0.01	0.01 M
1977						
Jan. 18	M	95	21.5	1.28	0.06	0.06 M
Feb. 2	un- known	29	0.5	0.02	0.05	0.05 unk.
Mar. 18	F	42	1.5	0.09	0.06	0.06 F
April 1	F	60	5.3	0.11	0.02	0.02 F
April 13	M	52	3.7	0.04	0.01	0.01 M
	F	53	4.5	0.06	0.01	0.01 F
April 23	M	66	7.0	0.01	0.00	
	M	59	4.7	0.00	0.00	0.01 M
	F	67	8.9	0.18	0.02	
	F	75	10.8	0.25	0.02	
	F	55	5.2	0.10	0.02	
	F	49	3.1	0.02	0.01	0.02 F

Table I. (Continued)

Month	Sex	S.L. (mm)	Wt. (gr)	Gonad Wt. (gr)	GSI	Ave. GSI per collection
April 30	F	94	29.0	0.22	0.01	
	F	83	17.7	0.19	0.01	
	F	73	11.5	0.14	0.01	
	F	79	12.0	0.70	0.06	
	F	67	7.3	0.04	0.01	
	F	57	5.6	0.04	0.01	0.02 F
May 13	F	76	12.1	0.12	0.01	
	F	56	6.1	0.05	0.01	
	F	57	6.0	0.04	0.01	0.01 F
	M	54	5.0	0.00	0.00	
	M	56	5.4	0.00	0.00	
	M	71	11.0	0.01	0.00	0.00 M

cesses in the male and the female. There is a continual production of spermatozoa within the lobules of the testis during maturation, whereas in the ovary maturation is concerned with the growth of existing oocytes. The germ cells of the ovary develop gradually with a smooth transition from stage to stage. The number of gametes produced from a germ cell differs greatly between the testis and ovary. Tailed sperm are present in the male testes as early as November, while fully developed eggs are not seen until April. The increase in size of the testis as maturity advances is a result of the increasing number of germinal cells; this contrasts with the condition in the ovary, where an increase in size of the gonad results from the increase in size of a fixed proportion of oocytes.

In assessing piraterperch according to their gonosomatic index (GSI), it is evident that the testes make up a larger proportion of total body weight in maturing males than do ovaries in the females, when compared in the same time period (Table I). The highest GSI in a male was in a November 29 specimen whose GSI was 1.10 or 10% of total body weight. In a female the highest figure was from a March 18 specimen whose GSI was 0.06 or 6% of total weight. In both males and females there is a gradual increase in the GSI from October through November; however, in December there is a decline in the GSI. The average female GSI from December 13 is higher than November 9, but not November 29. This might be attributed to the small sample size of November 29 (two specimens). The small number of males collected could also be the

reason for the rather erratic data associated with the male GSI from the fall and early winter.

In females collected in the spring there was a fairly even decline in the GSI from a high of 0.6 on March 18, to a low of 0.01 on May 13. A similar decline was seen in the male GSI. This decline carried through the assumed spawning period of April 1-13. In the April 30 collection one female had a GSI of 0.06 which was considerably higher than any of the others examined on that date. This specimen was assumed to be "egg bound," meaning that one or both of the oviducts may have been blocked, and a large proportion of the eggs remained unshed. This condition has been observed by several authors (Beach, 1959; Bowers and Holliday, 1961; and Bieniarz and Epler, 1976).

From the examination of the gonads of *Aphredoderus* collected at various times from September through May, it can be seen that the weight and the macroscopic and microscopic appearance of both testis and ovary vary at different periods. An abundance of fat surrounding the ovaries was seen in females taken in the early fall and in those specimens collected in the spring which were assumed to have spawned (spent condition). Fat was not seen in specimens which had near-ripe or ripe gonads. Craig-Bennett (1930), in observations on *Mugil*, *Salmo* and *Gasterosteus*, noted a similar reduction in the amount of fat at the time of maturation of the gonadal products. He believes, however, that there is no relationship between the development of fat and sexual maturity, and that the role of the fat is probably simply that of storage of

material, reflecting food abundance.

In September the lobules of the ripening testes were in the very early stages of spermatogenesis. As spermatogenesis advanced, the testes increased in size, and large quantities of sperm were found prior to spawning. With the extrusion of sperm during spawning, the size of the testes decreased considerably.

The increase in weight of the ovaries resulted from an increase in size of eggs brought about by the addition of yolk and, consequently, after spawning there was a decrease in weight. Two types of yolk were present in the developing eggs, the first type being noted in the October specimens. The second type of yolk appeared in the eggs of the April 1, 1977 specimen. Several investigators (Matthews, 1938; Bowers and Holliday, 1961; Merrett, 1970) have noted similar changes and have termed the type of yolk found in the April 1, 1977 specimen as secondary yolk. Bowers and Holliday (1961) contend that this secondary yolk differs from the primary or precursor yolk in that it is transferred from the blood vessels of the follicle to the egg. This transfer takes place at the latest maturity stages, i.e., just prior to ovulation.

The completion of spawning was followed by the resorption of any unextruded mature eggs and the development of corpora-lutea. The corpora-lutea of *Aphredoderus* are similar to those described for other species such as *Fundulus heteroclitus* (Matthews, 1938) *Gadus merlangus* and *G. esmarkii* (Gokhale, 1957) and *Clarias lazera* (Rizkalla, 1970). While the activity of *Aphredoderus* corpora-lutea was not assessed, the corpora probably function in steroidogenesis as suggested for other teleost species (Hoar, 1965; and Lambert and Van Oordt, 1965).

The determination of spawning period was deduced from the state of the male and female gonads, the weight of the gonads in relation to the overall body weight and the approximate age of the newly hatched fry. The calculated spawning period for pirateperch was the first two weeks in April.

Literature Cited

- Ahsan, S. N. 1966. Cyclical changes in the testicular activity of the lake chub, *Couesius plumbeus* (Agassiz). *Can. J. Zool.*, 44:149-171.
- Beach, A. W. 1959. Seasonal changes in the cytology of the ovary and the pituitary gland of the goldfish. *Can. J. Zool.*, 37:615-625.
- Bieniarz, K. and P. Epler. 1976. Preliminary results of the in vivo studies on ovarian resorption in carp (*Cyprinus carpio* L.). *J. Fish. Biol.*, 8:449-451.
- Bowers, A. B. and F. G. T. Holliday. 1961. Histological changes in the gonad associated with the reproductive cycle of the herring (*Clupea harengus* L.). *Mar. Res.*, 5:1-16.
- Cooper, L. J. 1952. A histological study of the reproductive organs of crappies (*Pomoxis nigromaculatus* and *Pomoxis annularis*). *Trans. Am. Microscop. Soc.*, 71:393-404.
- Craig-Bennett, A. 1930. The reproductive cycle of the three-spined stickleback, *Gasterosteus aculeatus*. *Philos. Trans.*, 219B:197-278.
- Foley, J. O. 1926. The spermatogenesis of *Umbra limi*. *Biol. Bull.*, 50:117-146.
- Forbes, S. A. and R. E. Richardson. 1920. The fishes of Illinois. 2nd edition. *Nat. Hist. Surv. Ill.*, Springfield., 228-231.
- Ginzburg, A. S. 1968. Fertilization in fishes and the problem of polyspermy. *Israel Prog. Scient. Trans. Jerusalem*, No. 600418, p. 63-86.
- Gokhale, S. V. 1957. Seasonal histological changes in the gonads of the whiting (*Gadus merlangus*) and the Norway pout (*G. esmarkii*). *Ind. J. Fish.*, 4:92-112.
- Hall, G. E. and R. M. Jenkins. 1954. Notes on the age and growth of the pirateperch, *Aphredoderus sayanus*, in Oklahoma. *Copeia*, 1:69.
- Hoar, W. S. 1965. Comparative physiology: Hormones and reproduction in fishes. *Ann. Rev. Physiol.*, 27:51-70.
- James, M. F. 1946. Histology of gonadal changes in the bluegill and largemouth bass. *J. Morph.*, 79:63-85.
- Jordan, D. E. and B. A. Evermann. 1896. The fishes of North and Middle America: a descriptive catalogue of the species of fishlike vertebrates found in the waters of North America, north of the isthmus of Panama. *Bull. U.S. Natl. Mus.*, 47:1-1240.
- Lambert, J. G. D. and P. G. W. T. van Oordt. 1965. Preovulatory corpora lutea or corpora atretica in the guppy, *Poecilia reticulata*. A. historical and histochemical study. *Gen. Comp. Endocrinol.*, 5:693-694.
- Mansueti, A. J. 1963. Some changes in morphology during ontogeny in the pirateperch, *Aphredoderus sayanus sayanus*. *Copeia*, 3:546-557.
- Martin, F. D. and C. Hubbs. 1973. Observations on the development of pirateperch, *Aphredoderus sayanus* (Pisces: Aphredoderidae) with comments on yolk circulation patterns as a possible taxonomic tool. *Copeia*, 2:377-379.
- Matthews, S. A. 1938. The seasonal cycle in the gonads of *Fundulus*. *Biol. Bull.*, 75:66-74.
- Merrett, N. R. 1970. Gonad development in billfish (Istiophoridae) from the Indian Ocean. *J. Zool. Lond.*, 160:355-370.
- Moser, H. G. 1967. Seasonal histological changes in the gonads of *Sebastes paucispinis*. *J. Morph.*, 123:329-353.
- Parker, N. C. and B. A. Simco. 1975. Activity patterns, feeding and behavior of the pirateperch, *Aphredoderus sayanus*. *Copeia*, 3:572-574.
- Rizkalla, W. 1970. Studies of the gonads of the teleost Nile fish, *Clarias lazera*. *Acta Veterinaria Acad. Hung.*, 20:1-12.
- Ross, K. F. A. 1953. Cell shrinkage caused by fixatives and paraffin wax embedding in ordinary cytological preparations. *Quar. J. of Micro Sci.*, 94:125-139.
- Stanley, H., G. Chieffi, and V. Botte. 1965. Histological and histochemical observations on the testis of *Gobius paganellus*. *Z. Zellforsch. Mikroskop. Anat.*, 65:350-362.
- Turner, C. L. 1919. The seasonal cycle in the spermary of the perch. *J. Morph.*, 32:681-710.
- Weisel, G. F. 1943. A histological study of the testes of the sockeye salmon (*Oncorhynchus nerka*). *J. Morph.*, 73:207-228.
- Wiebe, J. P. 1968. The reproductive cycle of the viviparous seaperch, *Cymatogaster aggregata* Gibbons. *Can. J. Zool.*, 46:1221-1234.

Upland Hardwood Forests of Pittsylvania County, Virginia

David Alan Clark and Stewart Ware

Department of Biology
College of William and Mary
Williamsburg, Va. 23185

Abstract—A study of twenty-two upland hardwood forests in Pittsylvania County, Virginia revealed two general types of forest. White oak forests, forming one type, were fairly diverse forests with *Quercus alba* being the major dominant and with *Acer rubrum* and *Liriodendron tulipifera* often obtaining high importance. Chestnut oak forests, the second class, were much less diverse forests with *Q. prinus* being the major dominant, and with *Q. alba* and *Q. coccinea* also attaining major importance. The forests of the latter type were generally found in poorer soils. The forests of this county resembled those previously studied in the Virginia and North Carolina Piedmont. However, *Quercus stellata*, important in Oosting's North Carolina study, and *Q. rubra*, reported as important in Gemborys's Prince Edward Co., Va. study, were both very low in importance. *Quercus coccinea*, reported to be low importance in other studies, was important in Pittsylvania Co. In general structure these forests are clearly a part of the Oak-Hickory-(Pine) Forest Region of Braun and Kuchler.

Introduction

The Piedmont of Virginia lies within the region designated by Braun (1950) and Kuchler (1964) as having oak-hickory-(pine) climax forests. This forest region covers the Piedmont Plateau and much of the Coastal Plain of the Atlantic and Gulf states, extending from Maryland and northern Virginia to as far south and west as eastern Texas. Pines are largely successional rather than climax (Oosting 1956, Braun 1950) but their abundance serves to distinguish the region from the Oak-Hickory Forest Region (Braun 1950) of the western part of the Eastern Deciduous Forest Formation. The three major successional species are *Pinus virginiana*, *P. echinata*, and *P. taeda*, though the latter two are absent from the northern part of the region. The major hardwood species widely distributed through the oak-hickory-(pine) region include *Quercus alba*, *Q. rubra*, *Q. velutina*, *Q. falcata*, *Q. stellata*, *Carya cordiformis*, *C. ovata*, *C. tomentosa*, and *C. glabra*, with *Oxydendrum arboreum*, *Cornus florida*, *Nyssa sylvatica*, *Acer rubrum* and *Liquidambar styraciflua* as typical subordinate species. Several other tree species may have local importance, but are not important throughout the region as are most of the above (Oosting 1956).

Studies have been made of upland hardwood forests in the North Carolina Piedmont (Oosting 1942), and Braun (1950) felt this area best exemplified the oak-hickory-(pine) climax forest region. Oosting (1942) placed the North Carolina Piedmont upland forests into two local classes of the general oak-hickory climax types. The more mesic class was characterized by *Quercus alba* and *Carya spp.*, with *Q. stellata* and *Q. velutina* also important, and the second type by *Q.*

stellata and *Q. alba*, with *Q. falcata* (*Q. rubra* by his nomenclature) also important. These two categories were named white oak and post oak forests, respectively. The post oak forests tended to occur in poorer soils and on drier ridges and knolls. Oosting (1942) found these two forest types to be closely related, but also found each to have distinct characteristics. Considering all these upland stands together, *Quercus alba*, *Q. stellata*, *Carya spp.*, *Q. coccinea*, and *Q. falcata* were the five major overstory species in order, with *Oxydendrum arboreum*, *Cornus florida*, and *Acer rubrum* the major understory species. *Quercus rubra* (his *Q. borealis*) was relatively unimportant, occurring in only 3.3% of the stands.

In a previous study of Virginia Piedmont hardwood forests, Gemborys (1974) examined the vegetational structure of forests in Prince Edward County, located in the south central Piedmont of Virginia. He reported the most important species in upland stands to be *Quercus alba*, *Q. rubra*, *Acer rubrum*, *Quercus prinus*, *Nyssa sylvatica*, *Q. falcata*, *Carya tomentosa*, and *C. glabra*. In sharp contrast to Oosting's (1942) findings in the North Carolina Piedmont, *Quercus stellata* was not a major species, while *Quercus rubra* and *Quercus prinus*, both unimportant in the North Carolina Piedmont, were each the leading dominant in 5 stands.

Pittsylvania Co. is in the Piedmont of Virginia, southwest of Prince Edward Co., and bordering on North Carolina. Thus it lies between the study sites of Gemborys (1964) and Oosting (1942). This paper reports on the composition of the upland hardwood forests of Pittsylvania County, analyzes interrelationships between stand compositions through an ordination model, examines possible relations between vegetational structure and environmental parameters, and compares the vegetation of this county with that described elsewhere in the Piedmont portion of the oak-hickory-(pine) forest region.

The Study Area

Pittsylvania is the largest county of Virginia, having an area of 1,015 square miles (2629 km²). It was "covered by magnificent woodland" before the settlement of the white man (Fuller *et al.*, 1925), but virtually no virgin tracts of hardwood forest remain today because of lumbering and cultivation. Because of the areal extent of the county and the development and cultivation of many areas, the stands selected were restricted to a centrally located, less developed portion

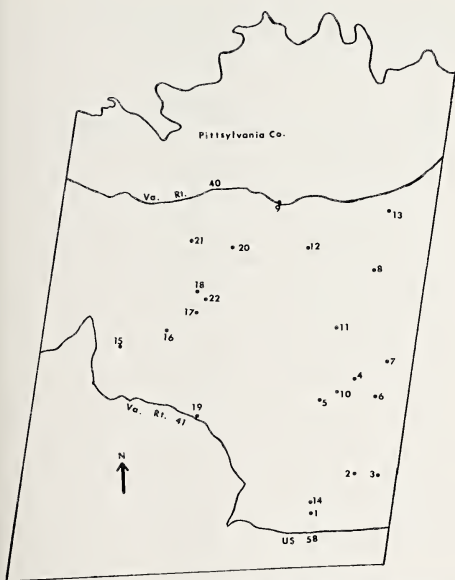


FIG. 1—Location of study sites in central and eastern Pittsylvania Co., Virginia.

of the county. This included the area of the county north of U.S. Highway 58, south of State Highway 40, and east of State Highway 21 (Fig. 1). The topography of this county is one of rolling hills, numerous streams, and generally good drainage. The upland soils are of several types, but by far the greatest percentage of them are of the Cecil series and of a sandy loam type (Fuller *et al.*, 1925).

The climate of Pittsylvania County is a relatively warm one. The summers are long and hot with an average mean temperature of 25.3°C, and the winters mild and short with an average mean of 4.2°C. The average frost free period extends from April 8 to October 24, a total of 199 days. The mean annual precipitation for Pittsylvania County is 101.6 cm (Fuller *et al.*, 1925).

Methods

In the summer and early fall of 1977, twenty-two stands were sampled which (1) were upland, (2) were predominantly hardwood, (3) showed no or little obvious signs of recent disturbance, (4) appeared to be uniform in composition, and (5) were at least 5 acres (2.02 ha) in area.

In each stand, dominance was determined by measuring basal area (cross-sectional area, breast high, in m²/ha) by the Bitterlich method, using a Spiegel Relaskop (angle gauge). Density for each species (in

trees/ha) was determined by counts of stems (>10.16 cm dbh) found within a circular plot of 10 meters radius. Relative dominance and relative density were calculated for each species, and an average of the two values was taken as the relative importance value (I.V.). Diversity of each stand was calculated using the Shannon-Weiner formula. Because of the difficulty in distinguishing between *Carya glabra* and *C. ovalis* during the summer months when mature fruit were not available, the practical policy employed by many foresters of lumping the two taxa as *C. glabra* was followed. Otherwise, taxonomic nomenclature follows Radford, Ahles, and Bell (1968).

An ordination of the 22 stands was established by using techniques based on those of Bray-Curtis as employed by Gemborys (1974) in his study of Virginia Piedmont forests. Because the third (Z) axis was highly negatively correlated ($r = -.91$) to the X axis, it provided no significant new information, and the ordination of the 22 stands presented here was established using only the X and Y axes. A tabular summary of structural characteristics and species importance values for all 22 stands are available upon request.

At each point sampled within a stand, the percent slope (using the Spiegel Relaskop) and direction of slope were recorded, and then these were averaged for the entire stand. Several (3 or 4) soil samples from the top 15 cm were collected at irregular intervals throughout each stand and were mixed well. A portion of each was forwarded to the Agricultural Cooperation Extension Service at VPI and SU in Blacksburg, Va., where the values for pH, Ca, Mg, P, K, and N were determined. The remaining soil was analyzed for sand, silt, and clay percentage in each stand using differential settling from aqueous suspension as employed by Bowers (1976). The process was performed twice for each soil sample and the two values averaged.

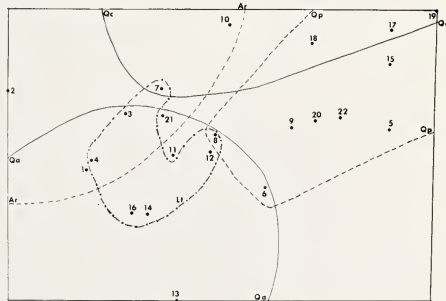


FIG. 2—Areas of concentration on the ordination of five major upland hardwood forest species. Upper right broken line (Qp) encloses stands with *Quercus prinus* I.V. > 20; lower left solid line (Qa), *Q. alba* I.V. > 16; upper solid line (Qc), *Q. coccinea* I.V. > 13; central dot-dash line (Lt), *Liriodendron tulipifera* I.V. > 10; upper left dotted line (Ar), *Acer rubrum* I.V. > 9.

Table I. Average importance values (IV), number of times each species was ranked as one of the top five species, number of stands where species was found, and highest IV obtained for the species.

Species	Number of times ranked					Average IV	Presence (out of 22)	Highest IV obtained
	1	2	3	4	5			
<i>Quercus alba</i>	10	4	5	3	0	20.8	22	50.9
<i>Quercus prinus</i>	7	2	1	2	0	21.1	16	74.9
<i>Acer rubrum</i>	2	2	1	2	3	6.9	19	23.1
<i>Quercus coccinea</i>	1	4	9	0	2	11.0	21	37.0
<i>Carya tomentosa</i>	1	0	0	1	1	3.3	15	19.0
<i>Quercus falcata</i>	1	0	1	0	0	2.6	13	23.4
<i>Liriodendron tulipifera</i>		4	2	0	2	6.7	13	23.6
<i>Nyssa sylvatica</i>		1	1	4	4	5.3	21	15.7
<i>Carya glabra</i>		1	0	1	3	3.3	15	12.3
<i>Pinus echinata</i>		1	0	1	1	3.0	14	13.8
<i>Oxydendrum arboreum</i>			4	2	2	4.8	18	12.1
<i>Pinus virginiana</i>			1	0	1	1.9	13	12.9
<i>Liquidambar styraciflua</i>				1	0	.9	3	12.1

Results

A total of 22 species were recorded in sample plots. *Quercus alba* and *Quercus prinus* were the two most important species, ranking first in I.V. in 10 and 7 of the 22 stands. Five other species were leading dominants in at least one stand (Table I).

Quercus alba was concentrated in the lower left-hand corner of the ordination (Fig. 2). It ranked among the top four species in I.V. in each of the 22 stands sampled, and was the most important species in 45% of them. In contrast, *Quercus prinus* was structurally more important in the stands of the upper right-hand portion of the ordination. Although it had the highest average importance value for the 22 stands, it occurred in only 73% of the stands and became one of the five leading dominants in only 55% of the stands. In several of the stands with a high importance value of *Q.*

prinus, many *Q. prinus* individuals were stump sprouts, very often with three to four large trunks growing from a single base. This may have produced inflated importance values in many of those stands heavily dominated by *Q. prinus* (since stems were counted at breast height). No other species was noted exhibiting multiple stump sprouts nearly as often. *Quercus prinus* reached its highest importance value of 74.9% in stand 5.

Quercus coccinea was concentrated in the upper section of the ordination. It occurred in 95% of the stands, becoming one of the five most important species in 73%. Much of its area of concentration on the ordination overlapped with that of *Q. prinus*.

Acer rubrum was concentrated in the upper left-hand corner of the graph. It occurred in most (86%) of the stands but was one of the five most important species in only 45% of them. *Acer rubrum* had the

fourth highest average importance value even though it generally occurred as an understory tree. Large, tall maples were encountered in the overstory, however, especially in ravines and draws.

Liriodendron tulipifera, *Quercus velutina*, *Nyssa sylvatica*, and *Oxydendrum arboreum* also were structurally important in the upland hardwoods of the county. The area of concentration for *Liriodendron* lies almost entirely within that of *Quercus alba* (Fig. 2). *Quercus velutina*, absent from only two stands, was concentrated in a lower left area bounded by and including stands 4, 21, 6 and 13. *Nyssa sylvatica* was very widespread, occurring in all but one stand, but the only stands where it reached an I.V. > 9 were stands 4, 3, 21, and 8. *Oxydendron arboreum*, also widespread, nevertheless achieved its greatest importance at higher y values: stands 3, 11, 20, 15 and those above have I.V. = 5.6-12.1; stands 2, 4, 8, 9, 22 and those below have I.V. = 0-5.4. *Quercus falcata*, though a leading dominant in one stand, achieved significantly high importance values for only two stands (stands 1 and 2), which lie in the far left side of the ordination.

The range of diversity extended from as low as .403 (stand 5) to 1.019 (stand 21). In general, stands that are more to the right had lower diversity than stands on the rest of the graph, though the most diverse stands centered in the mid-left section of the graph. Diversity was highly negatively correlated ($p = +.001$) to the x-axis, confirming the pattern detectable by inspection.

Soil analysis revealed generally low mineral availability and a narrow range for pH (4.3-5.3). In all except stand 7, the amount of nitrogen was negligible (< 5 lb/acre). The stands in the upper right portion of the ordination (stands 19, 17, 15, 18, 5, and 6, and to a lesser degree stands 22, 20, and 9) had generally lower values for Ca, Mg, K, and P, as well as pH, when compared with other stands. These were the nine stands which also had the highest *Quercus prinus* I.V. Indeed, each of the 4 minerals had negative correlation coefficients with both the x and y axes, although the only statistically significant correlations were the negative correlations with the x axis of Mg ($P = +.05$) and pH ($P = +.01$).

Average slope for each stand formed no specific pattern on the ordination though those stands on the right side of the graph, where $x > 50$, were slightly less sloping than those on the left. All those stands with x greater than 50 had a slope of less than 10%, whereas stands (except 11 and 1) on the left side of the graph had a slope greater than 10%.

Discussion

Two major types of stands were encountered in the upland hardwood forests of Pittsylvania County, with a few stands having intermediate characteristics. One type of forest, hereafter called chestnut oak forest, contained *Quercus prinus* as the major species and had a relatively low diversity. These stands all had an $x > 55$ (stand 9 and rightward, Fig. 2). *Quercus coccinea* and *Q. alba* were generally next to *Q. prinus* in impor-

tance, and *Oxydendrum arboreum* was the most common understory tree. In the forests of this type, no species other than the four mentioned above and the two successional pines (*Pinus echinata* and *P. virginiana*) obtained an importance value greater than 9.0.

The second type of forest included stands in which *Quercus alba* was important, usually as the leading dominant, and these stands had relatively high diversity. *Quercus prinus* was relatively unimportant, while *Acer rubrum* or *Liriodendron tulipifera* often ranked high in importance. All stands had an x value < 35 (stand 11 and leftward, Fig. 2). Two stands with $x < 35$ (stands 2 and 7) did not have *Q. alba* as the leading dominant; in these it ranked third and fourth respectively. However, these two stands had high diversity, had *Acer rubrum* ranked as one of the leading species above *Q. alba*, and had no *Q. prinus*. These stands, therefore, are considered in this second category, referred to as the white oak type of forest.

Five stands (6, 8, 10, 12, and 13) fell between the white oak and chestnut oak types. Diversity values lay between those of the other two groups, and stand composition often had similarities to both groups, with still another oak species, *Quercus velutina*, obtaining its two highest I.V.'s here.

In general, chestnut oak forests had gentler slopes, lower soil mineral availability, lower pH, coarser textured soils, and occurred more frequently in the western section of Pittsylvania Co., although there were two stands of this type well within the eastern part of the county. In stands of the white oak type, degree of slope, soil mineral availability, pH, and soil texture were more variable but were generally steeper, higher, and finer, respectively.

When all stands are considered together, the results place the forests of Pittsylvania Co. well within the oak-hickory climax described by Oosting (1956) and Kuchler (1964). All of the top seventeen species in importance in Pittsylvania Co. were among Kuchler's (1964) list of dominants and components of his oak-hickory-(pine) region.

The forest of the southern Piedmont of Virginia show similarities to the paradigmatic oak-hickory climax forests studied in the Piedmont of North Carolina by Oosting (1942). In both studies, two forest types were encountered, and one is characterized by high importance of *Quercus alba*, while the other type occurs in poorer soils. In our area, however, *Quercus prinus*, not *Quercus stellata*, is the dominant in this second forest type. Like Oosting (1942), we found *Quercus rubra* (his *Q. borealis*) to be unimportant, and *Quercus coccinea* to be among the several more important species. Our study sites have even greater similarities to these of Gemborys (1974) in Prince Edward Co. Prince Edward lies about 45 miles further east than Pittsylvania, and its southernmost border is about even with Pittsylvania's northernmost border. For the 24 upland forest stands ($x > 45$) he sampled in Prince Edward Co., Gemborys (1974) reported the eight most important species to be *Quercus alba*, *Q. rubra*, *Acer rubrum*, *Q. prinus*, *Nyssa sylvatica*, *Q. falcata*, *Carya*

tomentosa, and *Liriodendron tulipifera*. Except for *Quercus rubra*, all these occurred in over two-thirds of the stand sampled in Pittsylvania Co., and each was one of the two leading dominants in at least one stand. Of the twelve top species of Pittsylvania, all but two, *Q. coccinea* and *Q. velutina*, occurred in over 40% of the upland stands of Prince Edward Co. However, these three exceptions, *Q. rubra*, *Q. coccinea*, and *Q. velutina*, are very significant ones.

Quercus coccinea, occurring in 95% of the stands and holding the third most important position overall in the upland forests of Pittsylvania Co., was not reported once in either the tree layer or the sapling-shrub layer of any of the stands sampled in Prince Edward Co. by Gemborys (1974). *Quercus velutina*, occurring in 86% of the stands (and ranking among the top 4 species in 31%) in Pittsylvania Co., occurred in only 33% of the upland stands in Prince Edward Co., and did not rank among the top four species of a single stand. *Quercus rubra*, reported by Gemborys (1974) as his second most important species, occurring in 95% of the upland stands, was sampled in the tree layer of only one of the 22 stands sampled in Pittsylvania Co. Considering the short distance between the two counties,

additional study is needed to explain such differences between the two with respect to these three species.

Literature Cited

- Bowers, Lillian. 1976. How to judge your soil's texture. Flower and Garden, Sept., 1976, 36-37.
- Braun, E. Lucy. 1950. *Deciduous Forests of Eastern North America*. The Blakiston Co., Philadelphia, Pa., 596 pp.
- Fuller, Mabel C., Viola W. Shorter, and Landon E. Fuller. 1925. *Pittsylvania County Geography Supplement*. The County School Board, Pittsylvania County, Va., 32 pp.
- Gemborys, Stanley R. 1974. The structure of hardwood forest ecosystems of Prince Edward County, Virginia. *Ecology* 55: 614-621.
- Kuchler, A. W. 1964. *Potential Natural Vegetation of the Conterminous United States*. Special Publication No. 36. The American Geographical Society, New York, 116 pp.
- Oosting, H. J. 1942. An ecological analysis of the plant communities of Piedmont, North Carolina. *Am. Midl. Nat.* 28: 1-126.
- Oosting, H. J. 1956. *The Study of Plant Communities*. W. H. Freeman and Co. San Francisco, 440 pp.
- Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. *Manual of the Vascular Flora of the Carolinas*. Univ. of North Carolina, Chapel Hill, 1183 pp.

Book Review

The Marine Algae of Virginia. By Harold J. Humm. Illustrated. The University Press of Virginia, Charlottesville, Virginia. 1979. 263 pp. \$12.50.

Prior to the publication of this book there had been no comprehensive, convenient source of information to aid in the identification of marine algae growing along any region of the mid-Atlantic states. The author is well qualified to treat this subject and has produced a valuable and generally very usable guide to the microscopic and macroscopic benthic algae of Virginia. A relatively sparse marine flora is found along the numerous tidal rivers, bays and marshes, the Chesapeake Bay and the limited oceanic coastline (176 species are treated in this book; the author believes that over 200 will eventually be recorded), and many of these are restricted to periods of either warm or cold water temperatures. In spite of the small total number of species found during any season, the total number of individuals is often considerable and the other available keys from more northerly or southerly areas have often proven to be reliable only to genus designation at best.

The introduction includes a brief synopsis of the history of marine algal activities in Virginia, a discussion of the environmental features affecting local algal growth, occurrence and distribution, and general comments on the specific nature and relationships of Virginia algae in comparison to neighboring floras. A systematic list of species is presented and the major characteristics of each major group (Cyanophyta, Rhodophyta, Xanthophyta, Phaeophyta and Chlorophyta) is concisely discussed. Keys to the genera or species follows the introductory remarks of each division and there is an account of each class or subclass, order, family, genus and species. There are illustrations of a little over half of the described species, these being either photographs of herbarium specimens or drawings of entire or selected portions of plants. A short glossary is included as well as an adequate bibliography and index.

The major shortcoming of the book relates to the illustrations. Algae are widely recognized for their

extreme morphological plasticity. Photomicrographs or detailed drawings of critical vegetative and reproductive structures have always proven to be more reliable for macroscopic algae than photographs of herbarium specimens, especially when most of the latter are not accompanied by a scale, an inconsistency readily noticeable in this book. Also, some of the photographs are not especially clear (Fig. 39 of *Antithamnion cruciatum*, for example) or do not demonstrate the essential features used to distinguish between closely related species (Fig. 102, *Bryopsis plumosa* and Fig. 103, *B. hypnoides*), and a seemingly disproportionate photographic coverage is given to three brown algae which are not residents of Virginia and occur only in the drift (3 full plates of *Sargassum* species). Careful attention to the quality and appropriate types of illustrations is a difficult and time consuming job, but is immeasurably useful in algal keys, especially for students first introduced to seaweeds who more often than not include several herbarium specimens of hydroids in their general collection of "seaweeds".

The other noticeable deficiencies are found in the introductory remarks to some of the different algal groups. The statement that the Rhodophyta possess chlorophyll c is an unfortunate error and the well-known evidence of pit connections in the microscopic stages of some members of the Bangiophyceae no longer supports the author's contention that "there are no cytoplasmic connections between cells" in this red algal group. Also, some mention should have been made of the newly proposed systems of classification of the green algae which clearly indicate that more than gross morphological and life history considerations are necessary in modern taxonomic appraisals.

Overall the book is well organized, easy to use and is most definitely a welcome addition to the meager literature on the marine algae of the east coast of the United States. Harold Humm should be applauded for his efforts.

—Joe Scott, Biology Department,
College of William and Mary,
Williamsburg, Virginia.

NOTES

APPLICATION FOR MEMBERSHIP
VIRGINIA ACADEMY OF SCIENCE

Box 8454, Richmond, Virginia 23226

Name (Please Print) _____


Address (P.O. Box or Street) _____

City _____ State _____ Zip _____

Institution or Business _____

Position - Title _____

Field of Interest, Section No. _____

Date _____ Class of Membership Desired  ☐ Contributing ☐ Sustaining
☐ Regular ☐ Student
☐ Business

Contacted by: _____
 Make check payable to VIRGINIA ACADEMY OF SCIENCE and send to above address.

MEMBERSHIP

The Academy membership is organized into sections representing the various scientific disciplines.

Addressograph plates of all members are coded by First Number. The First Number indicates the member's primary interest and enables Section Officers to more easily contact members.

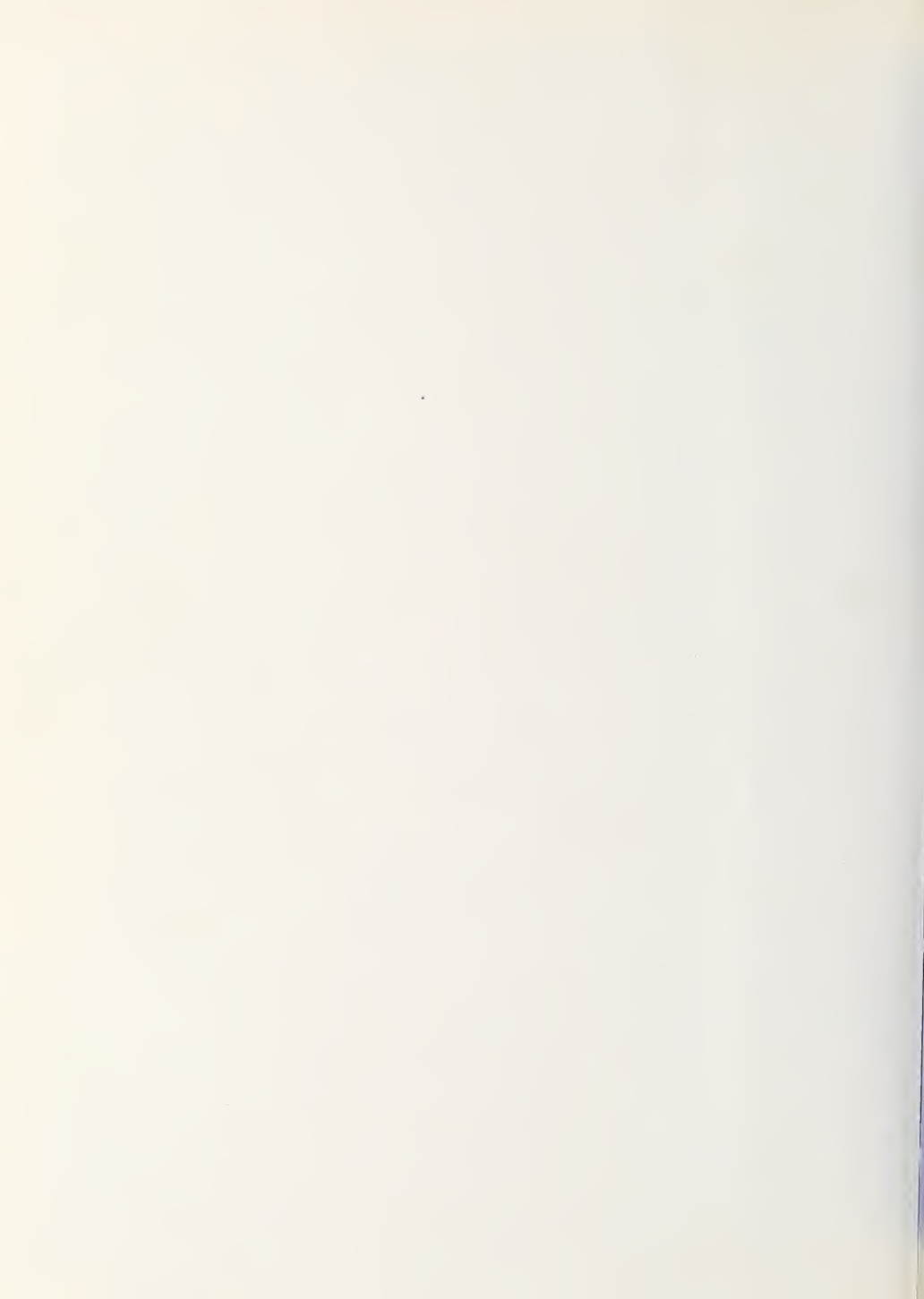
- | | |
|-------------------------------------|---------------------------|
| 1. Agricultural Sciences | 9. Medicine |
| 2. Astronomy, Mathematics & Physics | 10. Psychology |
| 3. Microbiology | 11. Education |
| 4. Biology | 12. Statistics |
| 5. Chemistry | 13. Space Technology |
| 6. Materials Science | 14. Botany |
| 7. Engineering | 15. Environmental Science |
| 8. Geology | |

Annual Membership Dues

Approved March 18, 1973

Business	Includes subscription to <i>Virginia Journal of Science</i>
Sustaining	
Contributing	
Regular	
Students	

*\$25 or more.



505,73
V81

VIRGINIA JOURNAL OF SCIENCE

VOL. 31, NO. 3
FALL 1980

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware
Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer
Box 637
Lancaster, Va. 22503

SECTION EDITORS

Agricultural Sciences

R. J. Stipes
417A Price Hall
VPI & SU
Blacksburg, Va. 24061

Physics

Dr. W. Peter Trower
Dept. of Physics
VPI & SU
Blacksburg, Va. 24061

Biology

Patrick F. Scanlon
Dept. of Fisheries & Wildlife
VPI & SU
Blacksburg, Va. 24061

Botany

David A. Breil
Dept. of Natural Sciences
Longwood College
Farmville, Va. 23901

Chemistry

Robert G. Bass
Dept. of Chemistry
Va. Commonwealth Univ.
Richmond, Va. 23284

Education

C. Dillard Haley
Dept. of Education
900 Fairfax St.
Radford, Va. 24141

Engineering

Walter R. Hibbard
301 Holden Hall
VPI & SU
Blacksburg, Va. 24061

Environmental Sciences

Michael Garstang
Dept. of Env. Science
Univ. of Virginia
Charlottesville, Va. 22904

Geology

Roddy V. Amenta
Dept. of Geology
James Madison Univ.
Harrisonburg, Va. 22801

Materials Science

John C. Duke, Jr.
Dept. of Eng. Sci. & Mechanics
VPI & SU
Blacksburg, Va. 24061

Medical Sciences

Charles O'Neill
Dept. of Biophysics
MCV
Richmond, Va. 23298

Microbiology

Paul V. Phibbs, Jr.
Dept. of Microbiology
MCV-VCU
Richmond, Va. 23298

Psychology

Frank S. Murray
Psychology Dept.
Randolph-Macon Women's
College
Lynchburg, Va. 24503

Space Science & Technology

Sam S. Fisher
Dept. of Mechanical and
Aero-Space Engineering
Thorton Hall, Univ. of Va.
Charlottesville, Va. 22901

Statistics

J. Van Bowen, Jr.
Dept. of Mathematics
Univ. of Richmond
Richmond, Va. 23172

©Copyright, 1980 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P.O. 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia and additional entry at Harrisonburg, Virginia 22801. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1980: \$15.00 per year, U.S.A.; \$20.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$4.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send address changes to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper (8½ × 11 inches). Margins should be not less than 1¼ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and affiliation, and proposed running title, all appear-

ing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first and last page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. *Metamorphic Textures*. Pergamon Press, New York. 350 pp.

Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians*, Part III. Vertebrates (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 31

No. 3

Fall 1980

TABLE OF CONTENTS

ARTICLES

- Modeling of a Solar-Pumped Iodine Laser. *J. W. Wilson, NASA, Langley Research Center, and J. H. Lee, Vanderbilt University* 34
- Downstream Changes in Fish Species Composition After Construction of a Headwater Reservoir. *Robert D. Young, Wisconsin Dept. of Natural Resources and O. Eugene Maughan, Oklahoma Cooperative Fishery Research Unit.* 39
- Graph Theory I: The Mathematics of Structure. *Thomas T. S. Huang, Dept. of Chemistry, East Tenn. State Univ., and George Sanzone, Virginia Polytechnic Institute and State University.* 42
- Kepone Uptake by Algae and Effects on Growth, Photosynthesis, and Respiration. *G. R. Young, J. A. Swader, and S. W. Bingham, Dept. of Plant Pathology and Physiology, Virginia Polytechnic Institute and State University.* 47
- Gall Formation and Life History of *Pineus floccus* (Patch) (Homoptera: Adelgidae) in Virginia. *Lucile Walton, 1116 Richmond Blvd., Danville, Va.* 55
- Phytoplankton Studies Within the Virginia Barrier Islands: I. Seasonal Study of Phytoplankton in Goose Lake, Parramore Island. *Harold G. Marshall, Old Dominion University.* 61
- Analysis of Site Specificity for Protein hydrolysis by the Alkaline Protease of *Neurospora crassa*. *Lloyd Wolfenbarger, Jr., Old Dominion University.* 65
- Obituary: John C. Strickland 68



Modeling of a Solar-Pumped Iodine Laser

J. W. Wilson

NASA Langley Research Center
Hampton, Virginia 23665

and

J. H. Lee

Vanderbilt University
Nashville, Tennessee 37235

Abstract—The direct conversion in space of solar radiation into laser radiation for power transmission to Earth, satellites, or deep space probes shows promise as a reasonably simple technology and may have cost advantage in deployment and greater reliability compared to other methods of space power generation and transmission. The main candidates for solar pumping are the gas dynamic, photochemical, and direct photoexcited lasers. We consider here the photochemical reaction of alkyl iodides which predominantly excite the $I(^2P_{1/2})$ state which then lasses at 1.315 μm . The iodine ground state is eventually lost to reconstituting the gas or in the formation of molecular iodine. The rates at which the gas is required to be recycled through the laser system are modest. The side exposure at 100-fold solar concentration of a 100-m long tube with a 1- m^2 cross section is estimated to provide 20 kW of continuous laser output. Scaling laws and optimum operating conditions of this system are discussed.

Introduction

The potential use of lasers for space power transmission is well recognized (Coneybear, 1978). Of the several options for the generation of laser beams in space, the direct conversion of solar radiant energy into a population inversion appears particularly attractive (Rather, 1978). The direct conversion in space of solar radiation into laser energy holds promise as a reasonably simple technology and may have cost advantages in deployment and greater reliability compared to other methods of space power generation. We develop herein a preliminary kinetic model for a solar-pumped atomic iodine laser. Some attention is given to the chemical reversibility and reprocessing requirements. A preliminary design of a small demonstration solar-power satellite for use in space is considered.

Kinetic Model

An energy level diagram for the photolytic-pumped alkyl iodide gas with the major kinetic pathways is shown in Figure 1. The alkyl iodide starting gas is represented by the symbol RI where R denotes the alkyl radical. Through photoabsorption denoted by the ascending zig-zag path, an excited RI* molecule is formed which dissociates in a free alkyl radical plus a metastable iodine atom I^* . The free alkyl radicals combine only slowly to form stable alkyl dimers R_2 . Alkyl recombinations with atomic iodine is fast once the iodine has reached its ground state. The free iodine

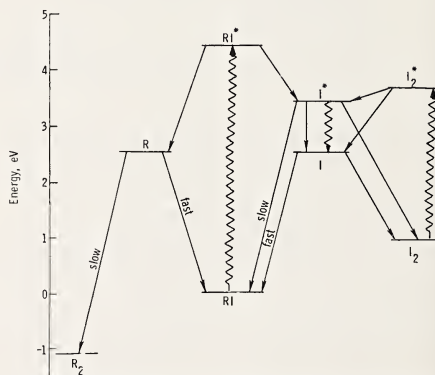


FIG. 1—Energy level diagram of the alkyl iodide photochemical laser showing kinetic pathways.

combines slowly to form iodine molecules which are subsequently photodissociated. The formation of alkyl dimers causes loss of material in the system which requires chemical reprocessing. Chemical reprocessing requirements are discussed subsequently. The corresponding rate coefficients are shown in Table I. The photodissociations denoted as the ascending zig-zag lines have their rates calculated according to a thermal source at temperature T . The air mass zero (AMO) solar UV emission corresponds to that of a blackbody with a temperature of 5400° K, although the visible and IR emission corresponds to temperatures of 5762° K. The unit solar concentration thus contains 1 percent of the insulation (1.4 kW m^{-2}) in the UV band from 250 to 300 nm. The photodissociation rates are found from the absorption line parameters in Table II. The photoemission denoted by the descending zig-zag line from the I^* has an Einstein A coefficient of 7.7 sec^{-1} (Beverly and Wong, 1977). The kinetic equations are taken from Beverly and Wong (1977) with source terms appropriate for solar pumping and disregarding the $I^* + I^*$ recombination included in their model. The

Table I: Chemical Reaction Rate Coefficients*

	Beverly-Wong	Hohla-Kompa	Fisk	Value Used	Symbol
$I^* + R \rightarrow RI$	$2.7 \text{ E} - 12$	-----	$1.5 \text{ E} - 12$	$1.5 \text{ E} - 12$	K_1
$I^* + I_2 \rightarrow I + I_2$	$(3.6 \pm 0.3) \text{ E} - 11$	$3.5 \text{ E} - 11$	$3.6 \text{ E} - 11$	$3.6 \text{ E} - 11$	Q_2
$I^* + RI \rightarrow I + RI$	$2.8 \text{ E} - 16$	$8.0 \text{ E} - 16$	-----	$8.0 \text{ E} - 16$	Q_1
$I + R \rightarrow RI$	$(1.5 \pm 0.5) \text{ E} - 10$	-----	$5.0 \text{ E} - 11$	$5.0 \text{ E} - 11$	K_2
$R + R \rightarrow R_2$	$4.2 \text{ E} - 12$	$1.0 \text{ E} - 11$	$1.5 \text{ E} - 13$	$1.5 \text{ E} - 13$	K_3
$I + I + I_2 \rightarrow 2I_2$	$7.4 \text{ E} - 32$	$2.9 \text{ E} - 30$	-----	$2.9 \text{ E} - 30$	C_4
$I^* + I + I_2 \rightarrow 2I_2$	$1.5 \text{ E} - 31$	$4.3 \text{ E} - 32$	-----	$4.3 \text{ E} - 32$	C_3
$I + I + RI \rightarrow I_2 + RI$	$7.8 \text{ E} - 33$	$4.5 \text{ E} - 31$	-----	$4.5 \text{ E} - 31$	C_2
$I^* + I + RI \rightarrow I_2 + RI$	$1.6 \text{ E} - 32$	$1.6 \text{ E} - 33$	-----	$1.6 \text{ E} - 33$	C_1

*Units for two-body coefficients are cm^3/s while three-body coefficients are cm^0/s

Table II: Photodissociation Parameters (Hohla and Kompa, 1976)

	σ_0, cm^2	$\lambda_0, \mu\text{m}$	$D_0, \mu\text{m}$
$\text{C}_3\text{F}_7\text{I}$	$5.4 \text{ E} - 19$	0.275	0.014
I_2	$17.0 \text{ E} - 19$	0.500	0.027

σ_0 - peak cross section

λ_0 - central wavelength

D_0 - rms bandwidth

$I^* + I^*$ recombination is inhibited due to the strongly repulsive $I^* + I^*$ potential. Hence

$$\frac{d[R1]}{dt} = K_1[R][I^*] + K_2[R][I] - S_1[R1]$$

$$\frac{d[R]}{dt} = S_1[R1] - K_1[R][I^*] - K_2[R][I] - 2K_3[R][R]$$

$$\frac{d[R_2]}{dt} = K_3[R][R]$$

$$\frac{d[I_2]}{dt} = C_1[I][I^*][R1] + C_2[I][I][R1] + C_3[I][I^*][I_2] + C_4[I][I][I_2] - S_2[I_2]$$

$$\frac{d[I^*]}{dt} = S_1[R1] + S_2[I_2] - K_1[R][I^*] - C_1[I][I^*][R1] - C_3[I][I^*][I_2] - Q_1[I^*][R1] - Q_2[I^*][I_2] - \Gamma_{23}^* - A[I^*]$$

$$\begin{aligned} \frac{d[I]}{dt} = & S_2[I_2] + Q_1[I^*][R1] + Q_2[I^*][I_2] + \Gamma_{23}^* + A[I^*] \\ & - C_1[I][I^*][R1] - 2C_2[I][I][R1] - C_3[I][I^*][I_2] \\ & - 2C_4[I][I][I_2] - K_2[R][I] \end{aligned}$$

$$\frac{d\rho}{dt} = h\nu \Gamma_{23}^* - \rho/\tau_c + h\nu A_0[I^*]$$

$$\Gamma_{23}^* = \omega_{23} \left([I^*] - \frac{[I]}{2} \right)$$

$$\omega_{23} = \lambda^2 A_{cp} / (4\pi^2 h \nu \Delta \nu)$$

$$\tau_c = - \left(\frac{1}{C} \right) \ln (r_1 r_2)$$

$$g = 2r_b^2 / L^2$$

where Γ_{23}^* is the stimulated emission rate, ω_{23} is the stimulation frequency, ρ is the intracavity photon energy density, τ_c is the lifetime of a photon in the resonator cavity, g is the geometric factor for the cavity, $\Delta \nu$ is the line width, L is the length of the laser cavity, r_1 and r_2 are end mirror reflection coefficients, and r_b is the laser beam width. The photodissociation rate coefficient of the isopropylidene (i-C₃F₇I) for the AMO solar spectral irradiance using the absorption parameters of Table II is

$$S_1 = 2.44 \times 10^{-3} C \text{ sec}^{-1}$$

where C is the solar concentration. Similarly, the iodine photodissociation rate coefficient is

$$S_2 = 4.2 \times 10^{-2} C \text{ sec}^{-1}$$

These dissociation rates are calculated by integration of the photoabsorption cross section (parameters in Table II) over the solar spectrum. The power output

per unit area of the laser beam cross section is

$$P = c \rho t_m$$

where t_m is the transmission factor for the output mirrors.

The kinetic equations were integrated numerically up to the time at which the laser output became steady. This value of steady output was then calculated for differing values of solar concentration and filling gas pressure. Using He as a buffer gas at 70 Torr for a laser tube 100-m long with a 10-percent output coupling mirror, results are shown in Figure 2 where power output is expressed as power per unit area of output beam per unit solar concentration as a function of the alkylidene mixing ratio. If the system efficiency was independent of solar concentration and alkylidene pressure, then the curves in Figure 2 would all lie on a single straight line. It can be seen from the figure that system inefficiencies begin to enter at high solar concentrations or at high alkylidene partial pressures. This implies that large laser volumes at low pressure are favored for space use.

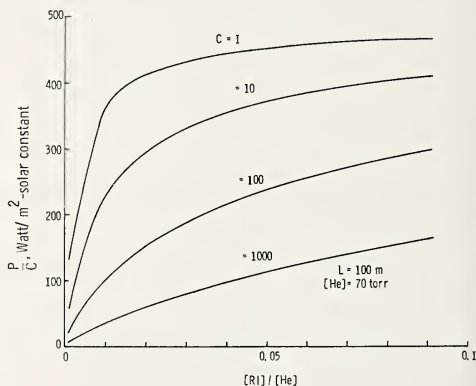


FIG. 2—Normalized solar-pumped laser output as a function of gas-mixing ratio for several solar concentration ratios.

When threshold is exceeded, the laser medium is saturated (i.e., the net gain is zero); the upper state and lower state population densities are related as

$$[I]_{\text{sat}} \approx 2[I^*]_{\text{sat}}$$

as seen from setting the stimulated emission rate Γ_{23}^* to zero. If we further assume that the alkyl-dimer is formed slowly as indicated in Figure 1, then

$$[R] \approx [I^*] + [I]$$

which follows from material conservation. Since a steady state the photodissociation source is nearly in

equilibrium with the alkyl-radical recombination rate, we have

$$\begin{aligned} S_1[R\dot{I}] &\approx K_1[R][I^*] + K_2[R][I] \\ &\approx 2/3K_2[R]^2 \end{aligned}$$

at saturation. The rate at which the alkyl-dimer is formed is given by

$$\frac{d[R_2]}{dt} = K_3[R]^2 \approx \frac{3}{2} \frac{K_3}{K_2} S_1[R\dot{I}]$$

The fraction of dissociations which are lost to dimers is then

$$F_{\text{loss}} = \frac{3}{2} \frac{K_3}{K_2} \approx 4.5 \times 10^{-3}$$

for the isopropyl iodide used here. Such dimers must be continuously removed from the gas and chemically processed to reform the lasant starting material. The removal of the dimers could be implemented with the circulation system for cooling the laser gas (Rather, 1978). It is clear from the above considerations that such recycling requirements for isopropyl iodide should not be prohibitive for space operation since only a small fraction of the alkyl radicals are lost to dimer formation.

Chemical reprocessing requirements can be further reduced by choosing alkyl radicals for which the rate of dimer formation is slower (i.e., smaller K_3). Figure 3 shows F_{loss} as a function of the dimer formation rate coefficient where data for various free radicals taken from Fisk (1977) are shown. The advantage of the T-butyl iodide over the isopropyl iodide is clearly evident from the figure. The isomeric structure will be of

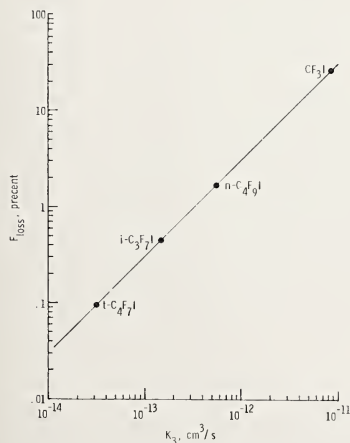


FIG. 3—Lasant material loss rate for several alkyl iodides.

further importance insofar as dissociation of the dimer in that the (t-butyl) - (t-butyl) will have a different resonance energy than a normal carbon-carbon bond which may be utilized in reforming the starting lasant material.

Satellite Power Station

We choose for a solar collector a parabolic cylindrical reflector with the laser tube at its focal line. A back reflecting right circular cylinder causes double traversal of the laser tube as shown in Figure 4. The parabola extends to only that part subtended by the latitudinal, ensuring all rays to pass through the laser tube twice. The effective solar concentration is given as

$$\frac{2f}{d} \leq C \leq \frac{16f}{\pi d}$$

where f is the focal length for the parabola and d is the mean diameter of the laser tube. The exact value of C depends on the alkyl iodide pressure. Taking d as 1 m and f as 50 m generates a concentration C of 100 for which the power output according to Figure 2 is about 20 kW for alkyl iodide concentrations of about 3 percent.

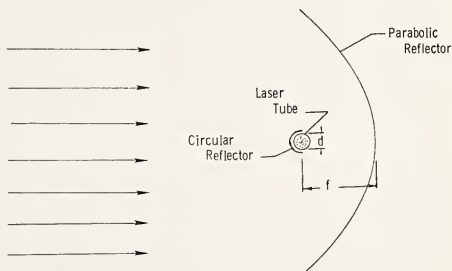


FIG. 4—Parabolic cylinder geometry for solar collector showing laser tube location.

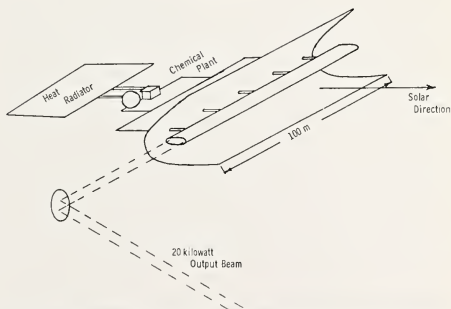


FIG. 5—A schematic view of a solar laser station with a 20-kilowatt output beam.

A possible configuration for a 20-kW solar-pumped laser facility is shown in Figure 5. The radiator size to reject the excess heat is about 100m^2 . The chemical reprocessing is not yet defined although preliminary work has been done by Fisk (1977). While future research will undoubtedly reveal more attractive candidates for solar-pumped lasers, the present study demonstrates the potential of such power-generating facilities in space.

Literature Cited

- Coneybear, J. F. (1978): The Use of Lasers for the Transmission of Power. *Radiation Energy Conversion in Space*, Ed. by K. H. Billman, *Progress in Astronautics and Aeronautics*, 61, 279.
- Beverly, R. E. and Wong, M. C. (1977): Transverse discharge excitation of the $1.315\text{ }\mu\text{m}$ atomic iodine laser II. Kinetic model. *Optics Communications* 20, 23.
- Fisk, G. A. (1977): The effects of chemical kinetics and starting material regeneration on the efficiency of an iodine laser amplifier. Sandia Lab., Albuquerque, NM. SAND77-0880.
- Hohla, K. and Kompa, K. L. (1976): The photochemical iodine laser. Chapter 12 of *Handbook of Chemical Lasers*, Ed. by R. W. F. Gross and J. F. Bott, Wiley and Sons, New York.
- Rather, J. D. G. (1978): New candidate lasers for power beaming and discussion of their applications. *Radiation Energy Conversion in Space*, Ed. by K. W. Billman, *Progress in Astronautics and Aeronautics*, 61, 313.

Downstream Changes in Fish Species Composition After Construction of a Headwater Reservoir

Robert D. Young

Wisconsin Department of Natural Resources
Rhineland, Wisconsin 54501

and

O. Eugene Maughan

Oklahoma Cooperative Fishery Research Unit
Stillwater, Oklahoma 74074

Abstract—Loss of cold water habitat resulting from reservoir construction resulted in the elimination of *Salvelinus fontinalis* (brook trout) and *Rhinichthys atratulus* (blacknose dace) from downstream areas of John's Creek, Virginia and was probably responsible for the absence of *Chrosomus oreas* and the reduction in numbers of *Cottus bairdi* downstream from the reservoir. Shallowness of the reservoir appeared to cause the higher downstream temperatures. The collective impact of improperly constructed impoundments in montane areas could result in significant losses of cold water habitats and associated species.

Introduction

Numerous small reservoirs have been built on the headwaters of small, cold water streams in recent years. The effects of these reservoirs on fish populations are generally assumed to be minor, but little published information is available to substantiate this assumption. In Virginia, there were 212 small reservoirs in 1977, and many more were being planned or constructed (Soil Conservation Service data file). Many of the existing reservoirs are located on cold water trout streams. Although the downstream effects of individual reservoirs on trout waters may not be great, collectively these impoundments affect a large percentage of the trout waters in the state. To evaluate the effect on downstream areas, we documented the effects on the fish species of one small headwater reservoir on John's Creek (Craig and Giles County, Virginia) where the fish population had been studied before construction of the reservoir by Burton and Odum (1945).

Study Site

John's Creek, a tributary of the James River, has a watershed of about 23,306 hectares. The upper portion (9.6 stream km) of the watershed consists of forested mountains and the lower portion (32.2 stream km) of

sparsely populated agricultural and wooded land. About 16 km below the origin, the creek enters an 11.3 hectare floodwater control reservoir constructed in 1965. The maximum depth of the reservoir is about 3.4 meters. The outflow facilities (multi level outlet) of this reservoir were designed to release cold, hypolimnetic water to protect the existing character of the stream.

Methods

Four sample stations were established; station 1 was 1.2 km upstream from the reservoir and the others were downstream at various distances below the reservoir—station 2 about 100 m, station 3 about 1.6 km and station 4 was 3.2 km. Fish populations were sampled in the fall of 1976 by blocking 50 meter sections at each station with nets and conducting sampling runs with a 230-V direct current electroshocker. Population estimates were made by the procedure recommended by Carle and Strub (1978). The removal method of population estimation involved three separate sampling runs, or removals, at each station. A mathematical relationship between the three concurrent removals was used to estimate the total fish population in each 50 meter segment. Species composition and distribution were then compared with pre-impoundment information presented by Burton and Odum (1945) for approximately the same sampling locations (their stations 1, 3, 4, and 5). Quantitative comparisons were not possible because Burton and Odum did not collect population data. Burton and Odum collected fish at each station by seining and dip netting one to two hundred yard stream segments.

Temperatures were measured 2 to 3 times a month from January to December 1976, at each station with a hand-held thermometer.

Results

The estimated number of individual fish was lower at each station below the reservoir than at the station above the reservoir, but the number of species collected was about the same at all stations (Table 1). The number of species taken at each station was higher than that reported by Burton and Odum (1945). Ten species were found both above and below the reservoir, whereas 5 were taken only upstream and 10 species were taken only downstream (Table 2).

Temperatures were similar above and below the reservoir from 1 November 1975 to 15 March 1976, and from 2 November 1976 to 1 December 1976 (range 2-8°C). From 15 March 1976 to 4 October 1976, downstream temperatures always exceeded those from the upstream station (range upstream 10-16°C, range downstream 11-23°C).

Table 1. Estimated fish populations (number of individuals per 50 meter stream segment) in John's Creek, 22 September 1976 and 14 October 1976.**

Species	Stations			
	1 (1.2 km upstream)	2 (100 m downstream)	3 (1.6 km downstream)	4 (3.2 km downstream)
Catostomidae				
<i>Catostomus commersoni</i>	(2)	-	(1)	
<i>Hypentelium nigricans</i>				
<i>Moxostoma rhothoecum</i>	*25	*19	*14	(*)
Centrarchidae				
<i>Ambloplites rupestris</i>				(2)
<i>Lepomis auritus</i>	9	(3)		(1)
Cottidae				
<i>Cottus bairdi</i>	*38	(*)2	(*)2	(*)1
Cyprinidae				
<i>Compositoma anomalum</i>	*14	*9	*16	*
<i>Chrosomus oreas</i>	34	*23	*23	(*)2
<i>Clinostomus funduloides</i>				*
<i>Exoglossum maxillingua</i>	(1)	*5		4
<i>Hybopsis micropogon</i>	*5	*20	*	*
<i>Lepomis auritus</i>		16	12	*13
<i>Notropis cornutus</i>		(1)	(1)	5
<i>N. ardene</i>		(1)		*
<i>N. sp.</i>		(1)		*
<i>Rhinichthys atratulus</i>	*32	*		
<i>R. cataractae</i>		6		
<i>Semotilus atromaculatus</i>			20	13
<i>S. corporalis</i>	43	30	7	*7
Esocidae				
<i>Esox a. americanus</i>		(2)		(1)
Italuridae				
<i>Noturus insignis</i>	2	21	10	1
Percidae				
<i>Etheostoma flabellare</i>	6	10	(2)	(1)
<i>E. longimanum</i>	*	*	(1)	*
<i>E. niger</i>	(1)			
<i>Percina peltata</i>				(1)
Salmonidae				
<i>Salvelinus fontinalis</i>	*7	*	*	*
Totals	248	163	109	51

* Found in this area by Burton and Odum (1945).

** When numbers captured were too low for a removal estimate (Carle & Strub 1978), actual catches (shown in parentheses) were used in place of estimates.

Discussion

Five species of fish were found only upstream from the reservoir (Table 2). In 1945, two of these species, *Salvelinus fontinalis* and *Rhinichthys atratulus*, occurred as far downstream as 4.0 km below station 4 but the other three species were not known to be present in

Table 2. Distribution of fishes in John's Creek after reservoir construction.

Location	Species
Upstream Only	<i>Catostomus commersoni</i>
	<i>Chrosomus oreas</i>
	<i>Etheostoma nigrum</i>
	** <i>Rhinichthys atratulus</i>
	** <i>Salvelinus fontinalis</i>
Downstream Only	*** <i>Ambloplites rupestris</i>
	<i>Esox a. americanus</i>
	<i>Etheostoma longimanum</i>
	*** <i>Hypentelium nigricans</i>
	<i>Notropis ardene</i>
	*** <i>N. cornutus</i>
	<i>N. sp.</i>
	<i>Percina peltata</i>
	<i>Rhinichthys cataractae</i>
	<i>Semotilus atromaculatus</i>
Upstream and Downstream	* <i>Compositoma anomalum</i>
	* <i>Clinostomus funduloides</i>
	* <i>Cottus bairdi</i>
	* <i>Etheostoma flabellare</i>
	* <i>Exoglossum maxillingua</i>
	* <i>Hybopsis micropogon</i>
	* <i>Lepomis auritus</i>
	* <i>Moxostoma rhothoecum</i>
	<i>Noturus insignis</i>
	<i>Semotilus corporalis</i>

* Similar distribution reported by Burton and Odum (1945).

** Restricted distribution after reservoir construction.

*** Extended distribution after reservoir construction.

the system. Absence of certain species from Burton and Odum's (1945) study could have been due to inefficient sampling gear.

In contrast, 10 species were found only downstream from the reservoir (Table 2). Three of these species were reported to occur only a considerable distance below the present reservoir in 1945; *Notropis cornutus* then occurred upstream only as far as station 4 and *Hypentelium nigricans* and *Ambloplites rupestris* penetrated upstream to a point several kilometers below station 4. Of the remaining seven species taken only downstream from the reservoir, six were not taken by Burton and Odum (1945) and the seventh, *Etheostoma longimanum*, was taken from sites both upstream and downstream from the reservoir location. We took only one specimen of *E. longimanum* (at station 3).

Burton and Odum (1945) collected one species, *Esox niger*, in the lower reaches of the stream (their stations 12, 13, 14, and 16) that did not occur in our samples. However, we collected *Esox americanus* at stations 2 and 4.

Ten species also occurred both above and below the reservoir (Table 2). Of these, eight seemed to be distributed equally upstream and downstream. *Noturus insignis*, one of the two remaining species, was scarce above the reservoir and the second, *Cottus bairdi*, was scarce below the reservoir. The original range of *C. bairdi* closely approximated that of *S. fontinalis* (Burton and Odum 1945).

Although a natural downstream transition in the fish community was observed by Burton and Odum

and us, that transition was not located in the same portion of the stream. In our study, the transition occurred abruptly at the reservoir. Burton and Odum did not see a similar change to warm water species until they were several kilometers below our station 4.

It is impossible to evaluate the effects of seasonal or annual differences on the distribution data; our data were taken in the fall and those of Burton and Odum were taken in the summer. However, except for *Salvelinus fontinalis*, these species are not known to show marked movements in summer and fall. Movements of *S. fontinalis* (brook trout) can occur in fall prior to spawning, when adult fish move to headwater areas (Scott and Crossman 1973). Movement of trout from John's Creek was not indicated, however, as *S. fontinalis* were found at Station 1. Therefore, it is probable that natural community changes were not responsible for the distribution we encountered.

Maximum summer temperatures at stations 2, 3, and 4 were between 21.0 and 23.0°C. Carlander (1969) reported upper lethal limits for *S. fontinalis* of between 21° and 26°C, depending on strain specific characteristics and 14°-19°C as preferred temperatures. High summer temperatures below the reservoir were probably responsible for elimination of the downstream trout population. Blacknose dace (*Rhinichthys atratulus*) are commonly associated with trout in cold water streams (Hubbs and Lagler 1958). It is likely that the high temperatures responsible for the elimination of trout from downstream areas of John's Creek also resulted in the loss of *R. atratulus* in those areas.

Higher downstream temperatures probably contributed to the absence of *Chrosomus oreas* and the scarcity of *C. bairdi*, even though maximum summer temperatures did not exceed lethal limits for these species.

Water temperature data collected at the same time as those collected for the present study showed that the shallow reservoir did not stratify during the summer, and that cold, limnetic water was not available for release downstream (Young 1977). The loss of trout habitat amounted to 7.2 stream km, which represents about 1/3 of the original amount present in John's Creek. Although this loss on one stream may not be important on a regional basis, the collective downstream impact of improper reservoir construction could be significant.

Literature Cited

- Burton, G. W. and E. P. Odum, 1945. The distribution of stream fish in the vicinity of Mountain Lake, Virginia. *Ecology* 26:182-194.
- Carlander, D. D. 1969. Handbook of freshwater fishery biology. Volume One. Iowa State University Press, Ames. 752 pp.
- Carle, F. L. and M. R. Strub, 1978. A new method for estimating population size from removal data. *Biometrics* 34:621-630.
- Hubbs, C. L. and K. F. Lagler, 1958. Fishes of the Great Lakes Region. The University of Michigan Press. Ann Arbor. 213 pp.
- Scott, W. B. and E. J. Crossman, 1973. Freshwater fishes of Canada. Bulletin 184. Fisheries Research Board of Canada. 966 pp.
- Young, R. D. 1977. Comparison of selected aquatic communities upstream and downstream of a headwater impoundment. M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg. 110 pp.

Graph Theory I: The Mathematics of Structure

Thomas T. S. Huang

Department of Chemistry
East Tennessee State University
Johnson City, Tennessee 37601

and

George Sanzone

Department of Chemistry
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061

Introduction

Chemical systems generally have structure; i.e. they contain elements (like atoms) which have interactions or connections (like bonds) between them. Whenever we can think of a structure as a set of elements connected by well-defined relations, there are many aspects of this structure which can readily be understood with what has come to be known as Graph Theory.[1-5] With this theory, structures can be classified according to their symmetries or general topology, and important reaction channels or paths through the structure can be identified. In this paper, some of the general aspects of graph theory are reviewed as well as its applications to chemistry. In another paper, a new flow graph, the Mass Balance Diagram, will be introduced as a tool in the study of reaction mechanisms. This diagram can be used to illustrate mechanisms (as linear combinations of elementary reactions), the stoichiometric number, and the distinction between a total mechanism and a Reaction Channel.

Graphs and Relations

Graph Theory is not concerned with the usual pressure-volume or temperature-time plots drawn to represent experimental or theoretical correlations. The graphs of Graph Theory are actually networks which indicate sets of elements together with the binary relations among pairs of these elements. Thus, a graph, $G = (\{x_i\}, R)$, is a finite set of elements, $\{x_i\}$, with a binary relation, R , defined on the set. An example of a graph would be:

$G_1 = (\{C_1, C_2, C_3, C_4\}, \text{is bonded to})$

If the relation maps the elements in the following way, the graph might represent the carbon skeleton for n-butane:

C_1 is bonded to C_2 ,
 C_2 is bonded to C_3 ,
 C_3 is bonded to C_4 .

The nature and specific properties of the relation will dictate the kind of graph it generates. Some examples are given in Table 1. Since the relation is central for the generation of a graph, it is useful to consider some definable properties of relations.

Table 1

Elements	Binary Relation	Kind of Graph
People	"is the parent of"	Family Tree
Cities	"is connected by rail to"	Railroad Map
People	"is in charge of"	Command Chart
Compounds	"combine to form"	Chemical Reaction
Atoms	"is bonded to"	Structural Formula

Symmetry

A relation R on a set $\{x_i\}$ is said to be symmetric if $x_i R x_j$ implies $x_j R x_i$. Any structural formula will illustrate a symmetric graph for, obviously, if atom A is bonded to atom B, then atom B is bonded to atom A.

If, however, only one of the following statement, $x_i R x_j$ or $x_j R x_i$, is allowed, then the relation (and the graph it generates) is said to be asymmetric or oriented.

For example, if our relation were "is older than", then either A is older than B or B is older than A. If every element in the set has the same age, then our relation is empty. (To avoid this kind of problem, the set of elements in the graph linked by the relation is usually defined to be a non-empty set.) Reversible reaction mechanisms will yield symmetric graphs while irreversible reactions will generate oriented graphs. Because so many reaction mechanisms are modeled with irreversible steps, the oriented graph can find much use in chemical kinetics; it also finds application in steady state situations, for example in the analyses of electrical circuits.[6]

Reflexivity

If for every x_i , $x_i R x_i$ applies, then the relation is said to be reflexive. It is non-reflexive if $x_i R x_i$ is not true for all of the members of the set.

Our previous example, "is older than", is non-reflexive. Examples of a reflexive relation are: "is isoelectronic with", and "is in equilibrium with".

Transitivity

If $x_i R x_j$ and $x_j R x_k$, then $x_i R x_k$, we say that relation R is transitive.

An example of a transitive relation in chemistry is found in the Zeroth Law of Thermodynamics: If A is in thermal equilibrium with B and B is in thermal equilibrium with C, then A is in thermal equilibrium with C. More simply: if A and B have the same temperature and B and C have the same temperature, then A and C have the same temperature. Non-transitive relations are easy to find. As an example: if A is 10 kilocalories more stable (ΔG) than B and B is 10 kcal more stable than C, then it does *not* follow that A is 10 kcal more stable than C.

Equivalence

A relation which is symmetric, reflexive and transitive is said to be an equivalence relation.

Ordinary equality is perhaps our most familiar equivalence relation. The equivalence relations in some branches of mathematics important for chemistry are given in Table 2. Any equivalence relation allows us to separate the elements of a set into equivalence classes. While equivalence relations are important in structural chemistry and statistical thermody-

namics, it is the non-equivalence relations which are important in chemical kinetics since these generate oriented graphs. The essential feature of asymmetric, transitive relations (which are non-equivalent) is that they allow the elements to be ordered in a definite way, e.g. as reactants, intermediates and products.

Representations

So far, our graphs have been defined abstractly in terms of a set and a mapping relation on this set. But because the relation is binary, any graph can be represented as a network diagram where the *vertices* correspond to the elements of the set and the *edges* (lines between vertices) correspond to the binary relations. In Figures 1 and 2, network representations of a symmetric and an oriented graph are illustrated.

Again, because the relation is binary, i.e. links only pairs of elements, any graph can be represented by a square matrix. If in the mapping $x_i R x_j$, we let i label the columns and j label the rows, then a matrix representation can be written at once. In the examples in Figures 1 and 2, we have entered a 1 whenever the relation applies and a 0 whenever it does not apply between the i^{th} and j^{th} elements of the set. Such matrices are called *associated matrices* but we prefer the term *matrix representations*. If the relation is non-

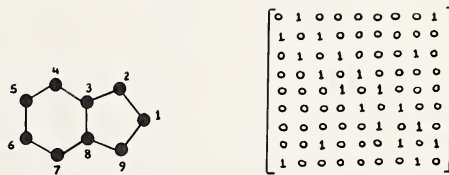


FIG. 1—Representations of a symmetric graph.

Table 2

Mathematics	Name
Arithmetic	Equality
Geometry	Similarity
Algebra	Isomorphism
Group Theory	Homomorphism

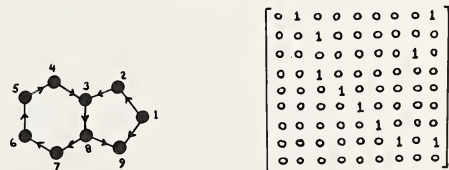


FIG. 2—Representations of an oriented graph.

reflexive, then only zeros will appear on the major diagonal ($x_i = x_j$) of the matrix. A symmetric relation will be represented by a matrix which is symmetric about its principal diagonal; i.e. the i - j th term will be equal to the j - i th term in the matrix. An oriented matrix will not be symmetric about its major diagonal. The matrix representation of a non-reflexive graph is often called an *adjacency matrix*. It is the adjacency matrix which figures so prominently in applications of graph theory to quantum chemistry.

There is much information in the adjacency representation which we can illustrate with reference to Table 3. In this table we have the network and adjacency matrix representation, $[A]$, for three graphs which differ only in their mapping relation. Graph I is symmetric while Graphs II and III are oriented. If we sum the matrix elements in the i th row of an adjacency matrix, we obtain the number of accessible nearest neighbors (or outgoing one-step paths) adjacent to the i th element of the set. Element 2 has 3, 1 and 2 accessible nearest neighbors in Graphs I, II and III, respectively. If, on the other hand, we sum the matrix elements in the j th column of an adjacency matrix, we find the number of nearest neighbors for which the j th element of the set is accessible, or alternatively the number of one-step paths which end at the j th element. Element 2 is immediately accessible from 3, 2 and 1 nearest neighbors in Graphs I, II and III, respectively.




			
$[A]$	$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$
$[A]^2$	$\begin{bmatrix} 0 & 1 & 0 & 1 \\ 0 & 3 & 0 & 2 & 0 \\ 1 & 0 & 2 & 0 & 2 \\ 0 & 2 & 0 & 2 & 0 \\ 1 & 0 & 2 & 0 & 2 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$
$[A]^3$	$\begin{bmatrix} 0 & 3 & 0 & 2 & 0 \\ 3 & 0 & 5 & 0 & 5 \\ 0 & 5 & 0 & 4 & 0 \\ 2 & 0 & 4 & 0 & 4 \\ 0 & 5 & 0 & 4 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$
$[A]^4$	$\begin{bmatrix} 3 & 0 & 5 & 0 & 5 \\ 0 & 13 & 0 & 10 & 0 \\ 5 & 0 & 9 & 0 & 9 \\ 0 & 10 & 0 & 8 & 0 \\ 5 & 0 & 9 & 0 & 9 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$

TABLE 3: THREE GRAPHS DIFFERING ONLY IN THEIR BINARY RELATION WITH THEIR ADJACENCY MATRICES, $[A]$, AND POWERS OF $[A]$.

In a symmetric graph, the number of one-step paths to and from a given element will be equal. If the symmetric graph is a chemical structure, then this number will be the number of bonds to or the valence of the atom at the vertex in question; if the symmetric graph is a reaction scheme, this number will be the number of reversible reactions or equilibria in which a given species is involved.

Next we might ask, what elements can be reached in a two-step process and how many two-step processes do we have for any given element. These questions are answered by considering the square of the adjacency matrix, $[A]^2$. Thus, summing the matrix elements of the 2nd row of $[A]^2$ indicates that there are 5, 1 and 0 two-step paths from element 2 in Graphs I, II and III, respectively. Similarly, summing the 2nd column of $[A]^2$ indicates that there are 5, 1 and 0 two-step paths to element 2 in Graphs I, II and III, respectively. Of particular interest are those two-step paths which return us to the starting element, i.e. two-step cycles. For example, there are 3 two-step paths which begin and end on the second element in Graph I; in chemical structure, these would be single bonds. If multiple paths between adjacent elements are considered, e.g. multiple bonds, then it is easy to demonstrate that the diagonal matrix elements of $[A]^2$ correspond to the sum of the squares of the multiplicities. Thus, if an atom has a double and two single bonds, the sum of its row (or column) in the adjacency matrix would be 4 while its diagonal element in the corresponding $[A]^2$ matrix would be $6 = 2^2 + 1^2 + 1^2$.

These considerations can be generalized. The $[A]^n$ matrix could be used to study n -step processes and non-vanishing diagonal elements of $[A]^n$ would indicate n -step cycles which begin and end at the corresponding vertex of the graph. For the graphs in Table 3, we find no three-step cycles are possible, but four-step cycles occur in Graphs I and II; no cycles at all are possible for Graph III. In fact $[A]^n$ vanishes for Graph III for n greater than 2. For Graph II, we find that $[A]^5 = [A]$ so that there is a periodicity in the n -step linkages in that graph.

These properties of the adjacency matrix cannot be new, yet chemists do not seem to have employed them. We discovered them simply by playing with graphs.

Another matrix representation which has been employed in chemistry is the *incidence matrix* $[B]$ which is a non-square matrix whose rows are labelled by the elements (vertices) and whose columns are labelled by the pairwise relations (edges) of the graph. An example of an oriented graph and its incidence matrix is given in Figure 3. The elements of the incidence matrix, B_{ij} are defined as follows:

$$B_{ij} = \begin{cases} 1 & \text{if vertex } i \text{ is the beginning of edge } j, \\ -1 & \text{if vertex } i \text{ is the end of edge } j, \\ 0 & \text{if vertex } i \text{ is not on edge } j. \end{cases}$$

The incidence matrix has been used to generate lists of potential isomers of compounds for which only the chemical formula and mass spectrum are known.^[7,8]

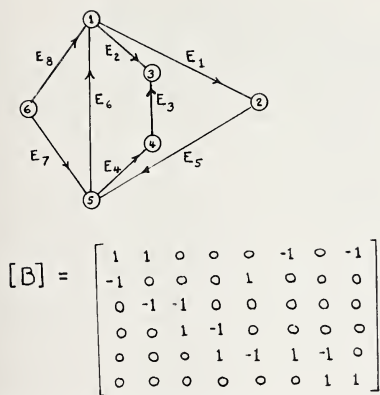


FIG. 3—A graph and its incidence matrix.

Paths and Graphs

The first known paper on graph theory was published in 1736 by Euler in which he resolved the Königsberg bridge problem.[9] This problem involves the discovery of a path having particular properties. The study of paths connecting the elements (vertices) of graphs is an important part of graph theory. It has guided the development of computer programming (flow charts), communications network analysis, critical path scheduling in operations research, and cryptography. Two important kinds of paths are the so-called Eulerian and Hamiltonian paths.

Eulerian Path:

A path which is closed and which traverses every edge exactly once is called Eulerian.

Hamiltonian Path:

A path which is closed but which traverses every vertex exactly once is called Hamiltonian.

To illustrate the distinction between these two kinds of path, suppose we are to conduct a tour of a campus which contains buildings of interest (vertices) and connecting walks and grounds (edges). If we plan a tour of the important buildings, and only wish to see them once, then we must find a Hamiltonian path on our campus map. If, however, we plan a tour of the grounds and do not wish to retrace any of the walks, we must find an Eulerian path through our campus.

The existence of a Hamiltonian path is related to the ergodic hypothesis of classical statistical mechanics. The necessary and sufficient conditions for the existence of a Hamiltonian path in a given graph is a major unsolved problem in graph theory. There is, however, a "soft" theorem due to G. A. Dirac:[4] If a graphs is simple, i.e. if every pair of its vertices is connected by only one edge, if there are n vertices, and if each vertex

is the end-point of $n/2$ paths, then a Hamiltonian path can be found. The theorem gives a sufficient but not a necessary criterion for the existence of an ergodic or Hamiltonian path. Figure 4 illustrates a Hamiltonian graph which satisfies Dirac's criterion.

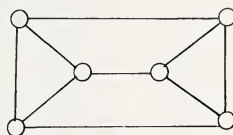


FIG. 4—A Hamiltonian Graph which satisfies Dirac's criterion.

The Euler path is illustrated in Figure 5 with the children's problem of drawing a house with one continuous line without retracing a line. Euler proved that if every vertex is the end-point of an even number of edges or if only two vertices are end-points of an odd number of edges, then an Eulerian path exists.[1]

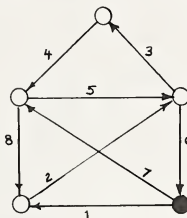


FIG. 5—An Eulerian Graph.

By assigning weights to the edges of a graph, one can order different paths according to preconceived priorities. This is the basis for critical path analysis which has been reviewed elsewhere.[2] The applications of graph theory to path analyses can involve rather more sophisticated mathematics than matrix algebra.

A Survey of Applications

The first applications of graphs in chemistry were probably the structural formulas introduced by Couper, Crum Brown, Frankland and Kekulé in their development of early valence theory. Today, they are the basis for characterizing both organic and inorganic compounds.[10-12] With the increasing use of computer search techniques, a number of nomenclature systems have been introduced which are based upon graph theory.[17, 13-15]

The determination of possible isomers was another early application of graph theory. This topic has been reviewed in depth by R. C. Read and A. T. Balaban.[1]

Perhaps the most widely pursued application of graph theory to chemistry is found in quantum chemistry.[16] In the zero-overlap approximation, the adjacency matrix (representing bonding interactions) commutes with the Hamiltonian in Huckel Theory. This fact has been used to good effect in determining the pi-electron energy spectrum of homo- and heterocyclic compounds. A number of very good reviews of these applications are available.[1, 5, 17] In considering these reviews it is interesting to note how much of the success of the Huckel Molecular Orbital approach is due to the validity of the graphical structural formula and how little is due to the detailed quantum assumptions.

The use of graphs in statistical thermodynamics is perhaps best represented in the cluster expansions of Mayer[18] and in the polymer studies of Gordon.[1]

Although graph theory has found many significant applications in path analysis, its application to reaction networks has not been well developed. Happy exceptions are the stability analyses of Clarke[19] and the study of the possible stereoisomers of pentacoordinate complexes via a Berry process.[20, 21]

Concluding Remarks

The authors have found graph theory to be both fun and interesting, but they have also found it to be important for chemistry. We hope that this brief review will transmit some of our new-found enthusiasm and that others will be stimulated to read about this field of applied mathematics. We are convinced that graph theory should be given equal time with group theory (which can be considered a subdiscipline) in chemistry curricula.

This work was done under a grant from the U.S. Energy Research and Development Agency.

References

1. Balaban, A. T. (editor), "Chemical Applications of Graph Theory", (Academic Press, N.Y., 1976).
2. Bondy, J. A. and Murty, U.S.R., "Graph Theory With Applications", (Amer. Elsevier, N.Y., 1976).
3. Wilson, R. J., "Introduction to Graph Theory", (Academic Press, N.Y., 1972).
4. Harary, F., "Graph Theory", (Addison-Wesley, Reading, Mass., 1969).
5. Gutman, I. and Trinajstić, N., in "Topics in Current Chemistry, vol. 42: New Concepts II", (Springer-Verlag, N.Y., 1973).
6. Pullen, Jr., K. A., "Theory and Applications of Topological and Matrix Methods", (J. F. Rider, Publisher, N.Y., 1962).
7. Gluck, D. J., J. Chem. Doc. 5 (1), 43 (1965).
8. Buchanan, B. G., Sutherland, G. L. and Feigenbaum, E. A., "Machine Intelligence, vol. 4," Meltzer and Michie, eds., (Edinburgh Univ. Press, Edinburgh, 1969).
9. Euler, L., Comment. Sci. I. Petropolitanae, 8, 128 (1736); translated in Sci. Amer. 189, 66 (1953).
10. Wells, A. F., "Structural Organic Chemistry, 3rd edition," (Oxford Univ. Press, Clarendon, 1962).
11. Lipscomb, W. N., Science 153, 373 (1966).
12. Gillespie, P., Angew. Chem. 83, 691 (1971).
13. Penny, R. H., J. Chem. Doc. 5, 113 (1965).
14. Spialter, L., J. Chem. Doc., 4, 261, 269 (1964).
15. Lederberg, J., et al., J. Amer. Chem. Soc. 91, 2973 (1969).
16. Coulson, C. A., Proc. Camb. Phil. Soc. Math. Phys. Sci. 46, 202 (1950).
17. Gutman, I., et al., J. Chem. Phys. 61, 2700 (1974); 62, 338 (1975).
18. Mayer, J. E. and Mayer, M. G., "Statistical Mechanics", (Wiley, N.Y., 1940).
19. Clarke, B. L., J. Chem. Phys. 60, 1481, 1493 (1974).
20. Ugi, I. et al., Accounts Chem. Res. 4, 288 (1971).
21. Muettterties, E. L., J. Amer. Chem. Soc. 90, 3097 (1968).

Kepone Uptake by Algae and Effects on Growth Photosynthesis and Respiration

G. R. Young, J. A. Swader, and S. W. Bingham

Department of Plant Pathology and Physiology
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061

Abstract—The insecticide Kepone inhibited growth, photosynthesis, and respiration of *Chlorella sorokiniana* and *Chlorococcum hyposporum*. The insecticide reduced rates of respiration more than photosynthesis. Uptake of ^{14}C -Kepone by the algae was proportional to cellular concentration. A net efflux of Kepone was exhibited by *Chlorella* cells after 30 minutes of incubation, whereas, equilibrium occurred within 15 minutes of incubation for *Chlorococcum*. Desorption of Kepone was evident when both algal species were removed from Kepone treated solutions and incubated in untreated nutrient solutions.

Introduction

Contamination of the James River in Virginia by the insecticide Kepone (decachlorooctahydro-1,3,4-metheno-2H-cyclobuta cd pentalen-2-one) poses a threat to aquatic and terrestrial biota as indicated by the toxicity, bioconcentration and bioaccumulation of Kepone in estuarine organisms (Hansen et al., 1976 and Hansen et al., 1977). Its presence in water has become increasingly important as a determining factor on the quality of the environment. Removal of Kepone from the environment may occur slowly by degradation. The role that aquatic organisms play in removal of Kepone is not clear. The accumulation of pesticides by aquatic organisms may alter the organisms' metabolism, result in biodegradation of the pesticide, cause death of the organisms, or a combination of these. Reports have indicated resistance of some organisms (i.e. algae) to particular pesticides and survival of these organisms even though they accumulate pesticides to levels much higher than those in the external environment (Menzel, 1970; Vance and Drummond, 1969; Wurster, 1968). Accumulated and persistent pesticides are distributed to areas away from the source of the pollutant by mobile organisms and flowing water.

Algae are common aquatic organisms and they alter water quality by modifying pH, color, turbidity and concentration of inorganic and organic compounds. In recent years, algae were shown to accumulate and produce toxic substances which affect wild and domestic animals (Palmer, 1962). Algae are somewhat resistant to certain organic compounds such as herbicides (Valentine and Bingham, 1976) and chlorinated insecticides and, as a result of accumulation, can cause severe effects on organisms higher in the food chain (Vance and Drummond, 1969; Bahner et al., 1977).

The objectives of this research were to evaluate uptake and accumulation of Kepone by two species of green algae, and to determine the effects of the insecticide on algal growth, photosynthesis, and respiration.

Materials and Methods

Algal culture. *Chlorella sorokiniana* Shihira and Kraus and *Chlorococcum hyposporum* Starr were grown under aseptic conditions in 0.5 strength Bold's basic medium (James, 1974), pH 7.0, at room temperature with a light intensity of $90 \mu\text{E}\cdot\text{m}^{-2}\cdot\text{sec}^{-1}$ provided by fluorescent lamps and aerated with filtered, humidified, compressed air. Light intensity was measured with a Lambda Model LI-170 quantum meter.

Effect of Kepone on algal growth. After 4 days of growth, the cells were harvested by centrifugation, $300 \times g$ for 2 min, resuspended in sterile nutrient solution, pH 8.0, and counted with an improved Neubauer counting chamber. The cells were transferred to 125 ml Erlenmeyer flasks, 50 ml per flask, and treated with 0.5, 1.0, 1.5, and 2.0 ppm (w/v) of Kepone. Four replications of each treatment were prepared. Stock solutions of Kepone were prepared in acetone and the same amount of acetone, 2.5 μl , was also added to the controls. The flasks containing the algae were placed on a rotary shaker set at 80 excursions $\cdot\text{min}^{-1}$ under fluorescent lamps with $85 \mu\text{E}\cdot\text{sec}^{-1}$ at the surface of the treated culture solutions. The algae were incubated under aseptic conditions at 25°C and aerated with 200 $\text{cm}^3\cdot\text{min}^{-1}$ of filtered, humidified, compressed air. Initial cell concentrations were 1×10^5 *Chlorella* cells $\cdot\text{ml}^{-1}$ and 4×10^4 *Chlorococcum* cells $\cdot\text{ml}^{-1}$.

Effect of Kepone on photosynthesis and respiration. Algal cells were harvested from the growth experiment after 96 hr of incubation with Kepone, resuspended in sterile nutrient solution, and the photosynthetic and respiratory rates were determined by measuring changes in oxygen concentration in solution with a Gilson Medical Electronics Oxygraph, Model K-ICC, equipped with a Clark electrode and a 2 ml glass reaction chamber. The reaction chamber was enclosed in a glass water jacket maintained at 25°C with a constant temperature circulating water bath. The reaction chamber was illuminated with one 300 W, 120 V, Ken-Rad reflector lamp placed on each side of the reaction cell. Each lamp provided $2000 \mu\text{E}\cdot\text{m}^{-2}\cdot\text{sec}^{-1}$ at the surface of the reaction vessel. Tap water flowing through a Pyrex container between each lamp and the reaction chamber served as a heat filter. Respiration was measured in the dark and photosynthetic rates are corrected for dark respiration. Cell concentration for *Chlorococcum* was 6×10^6 cells $\cdot\text{ml}^{-1}$ in both photosynthesis and respiration experiments; for *Chlorella*, it

was 1×10^7 cells·ml⁻¹ in the photosynthesis experiments, and 1×10^8 cells·ml⁻¹ in the respiration experiments. Chlorophyll content was measured by the method of Arnon (1949). The data were tabulated as averages of 5 replications.

Removal of Kepone from solution by algae. Algal cells grew in nutrient medium for 4 days, were harvested by centrifugation, resuspended in sterile nutrient medium, transferred to a 6 liter Erlenmeyer flask, 3 liters per flask, and aerated with 500 cm³·min⁻¹ of filtered, humidified, compressed air. After 10 days in a growth chamber at 25° and 85 μ E·sec⁻¹, the algae were harvested, and each of the following cell concentrations, 1×10^6 , 5×10^6 , and 1×10^7 cells·ml⁻¹ of *Chlorella* and 1×10^5 , 5×10^5 , 1×10^6 cells·ml⁻¹ of *Chlorococcum*, were suspended in 500 ml of nutrient solution containing ¹⁴C-Kepone, pH 7.0. *Chlorella* and *Chlorococcum* were exposed to ¹⁴C-Kepone concentrations of 60.9 μ g·l⁻¹ (2.17 μ Ci·ml⁻¹) and 59.2 μ g·l⁻¹ (2.12 μ Ci·ml⁻¹), respectively. Each cell concentration was replicated 5 times in 125 ml Erlenmeyer flasks containing 1% ml of algal suspension. The cells were incubated for 24 hr at 25°C on a rotary shaker at 80 excursions·min⁻¹ under a light intensity of 15 μ E·m⁻²·sec⁻¹. A complete set of flasks with nutrient solution without algae was also included to serve as a control. At each sampling interval, the flasks were shaken by hand, 4 ml aliquots from each flask were centrifuged at 3000 X g for 2 min, 0.5 ml of each supernatant was added to 3 ml of Aquasol (New England Nuclear), and radioactivity was determined with a Beckman, Model LS-250, liquid scintillation counter. The samples were corrected for quenching and the data are expressed as disintegrations·min⁻¹ (DPM)·ml⁻¹ remaining in solution. An aliquot of the algal cells was counted at the termination of the study and percent increase in cell numbers was calculated.

Efflux of Kepone from algal cells. Aliquots of 4 ml were removed from each of the 5 replicates for each cell concentration of the uptake experiment at the termination of the 48 hr incubation. The cells were harvested from ¹⁴C-Kepone solution by centrifugation at 3000 X g for 2 min and resuspended and washed 3 times with sterile nutrient medium. After washing, the cells were resuspended in 2 ml of sterile nutrient solution, incubated for 20 min under the same conditions used in the uptake study, centrifuged, and ¹⁴C in 0.5 ml of supernatant in 3 ml Aquasol was measured with the liquid scintillation counter. The samples were corrected for quenching and the data are expressed as DPM·ml⁻¹ for each algal cell concentration.

Analysis of data. The data was tested for significance at the 5% level of confidence according to Duncan's Multiple Range Test (Sokal and Rohlf, 1969). All experiments were repeated with results similar to those reported.

Results and Discussion

Influence of Kepone on algal growth. *Chlorella* growth was inhibited by 2 ppm of Kepone after 24 hr of

incubation (Table I). The growth of *Chlorella* was also inhibited by 1 ppm of Kepone during the 48 hr incubation. The growth of *Chlorococcum* was inhibited by 1.5 ppm of Kepone during the 24 hr incubation and by all concentrations of Kepone tested during the 48 hr exposure (Table II). After 96 hr of incubation, *Chlorella* growth was inhibited by Kepone concentrations greater than 0.5 ppm, but the growth of *Chlorococcum* was only inhibited by the highest concentration, indicating recovery from the Kepone effect.

TABLE I
Effect of Kepone on Growth of *Chlorella*

Kepone (ppm)	Cells $\times 10^{-5}$ /ml ^a / Hours of incubation			
	12	24	48	96
0.0	2.0 a	5.8 a	38 a	357 a
0.0 + Acetone ^b /	1.9 a	5.4 ab	35 ab	356 a
0.5	1.9 a	5.8 a	30 bc	324 ab
1.0	2.0 a	4.2 ab	27 c	254 bc
1.5	1.9 a	3.8 bc	29 bc	254 bc
2.0	1.9 a	2.6 c	23 c	232 bc

^a/Values in each column are the means of four replicates and those followed by the same letter within each column are not significantly different at the 5% level of confidence according to the Duncan's Multiple Range Test.

^b/Stock solutions of Kepone were prepared with acetone and the same volume of acetone, 0.5 μ l/ml, was added as in the Kepone treatments.

TABLE II
Effect of Kepone on growth of *Chlorococcum*

Kepone (ppm)	Cells $\times 10^{-5}$ /ml ^a / Hours of incubation			
	12	24	48	96
0.0	0.62 a	1.02 a	2.6 a	13.4 a
0.0 + Acetone ^b /	0.67 a	0.86 b	2.5 a	12.8 a
0.5	0.60 a	0.80 b	1.8 b	12.4 a
1.0	0.65 a	0.75 b	1.6 b	12.3 a
1.5	0.60 a	0.60 c	1.1 c	9.0 a
2.0	0.60 a	0.60 c	0.6 c	2.6 b

^a/Values in each column are the means of four replicates and those followed by the same letter within each column are not significantly different at the 5% level of confidence according to the Duncan's Multiple Range Test.

^b/Stock solutions of Kepone were prepared with acetone and the same volume of acetone, 0.5 μ l/ml, was added as in the Kepone treatments.

These results show that Kepone reduced the rate of algal growth. The concentrations of Kepones and algal cells used in these experiments were greater than those found in the James River (United States Environmental Protection Agency, 1978). Lower concentrations than those used in this study of various other chlorinated hydrocarbon pesticides were toxic to algae (de la Cruz and Naqvi, 1973; Vance and Drummond, 1969; Wurster, 1968; Menzel et al., 1970; Butler, 1963); however, Hollister et al. (1975) found that Mirex, a compound with molecular structure similar to Kepone, did not affect growth when various species of algae were

exposed to 0.2 ppb. Growth of algae in the James River may be affected by the Kepone contamination, especially in shallow water (up to 60 cm deep) locations containing the higher concentrations (1 ppm up to 10 ppm in the bottom sediment).

Effect of Kepone on respiration. Respiration of *Chlorella* and *Chlorococcum* was reduced by 47 and 37%, respectively when cells were exposed to 1 ppm of Kepone for 96 hr (Table III). These results support observations of de la Cruz and Naqvi (1973) that 1 ppm of Mirex inhibited respiration of *Chlamydomonas*.

TABLE III
Effect of Kepone on Respiration

Kepone (ppm)	$\mu\text{mol O}_2$ Consumed	
	(mg dry wt) ⁻¹ /hr ^{a/} <i>Chlorella</i>	<i>Chlorococcum</i>
0.0	32 a	99 a
0.0 + Acetone ^{b/}	36 a	92 a
1.0	19 b	58 b

^{a/} Values in each column are the means of five replicates and those followed by the same letter within each column are not significantly different at the 5% level of confidence according to the Duncan's Multiple Range Test.

^{b/} Stock solutions of Kepone were prepared with acetone and the same volume of acetone, 0.5 $\mu\text{l/ml}$, was added as in the Kepone treatments.

Mitochondria have many important roles in plant and animal cells and are a source of energy for metabolic functions. Chronic influences of various pesticides has been shown to interfere with cellular functions (Pardini et al., 1971). Mitochondrial membranes, as well as other cellular membranes, contain a high content of phospho-lipids. Since organochlorine pesticides are lipid-soluble, it is expected that cellular membranes absorb a high concentration of these chemicals which interfere with mitochondrial function (Pardini et al., 1971). Some of the pesticides which inhibit respiration are heptachlor, chlordane, toxaphene, rotenone, Mirex and Kepone (Pardini et al., 1971; Byard et al., 1975; Anderson et al., 1977; Anderson et al., 1978; Desai and Koch, 1975; Desai et al., 1977).

Since Kepone inhibits the animal ATPase, lactate, malate and glutamate dehydrogenases *in vitro* (Desai et al., 1976; Anderson et al., 1978; Anderson et al., 1977; Freedland and McFarland, 1965) it is probable that Kepone affects these same enzymes in plant cells.

Effect of Kepone on photosynthesis. Kepone at 1 ppm reduced rates of photosynthesis of *Chlorella* and *Chlorococcum* 17 and 10%, respectively, after 96 hr. of incubation (Table IV). Effects of chlorinated hydro-

TABLE IV
Effect of Kepone on Photosynthesis

Kepone (ppm)	$\mu\text{mol O}_2$ Evolved	
	(mg chlorophyll) ⁻¹ /hr ^{a/} <i>Chlorella</i>	<i>Chlorococcum</i>
0.0	66 b	34 a
0.0 + Acetone ^{b/}	76 a	34 a
1.0	63 b	31 b

^{a/} Values in each column are the means of five replicates and those followed by the same letter within each column are not significantly different at the 5% level of confidence according to the Duncan's Multiple Range Test.

^{b/} Stock solutions of Kepone were prepared with acetone and the same volume of acetone, 0.5 $\mu\text{l/ml}$, was added as in the Kepone treatments.

carbons on photosynthesis of algae have been previously documented, but the mechanism is not understood (Menzel et al., 1970; de la Cruz and Naqvi, 1973). Some reports suggest that chlorinated hydrocarbons inhibit the Hill reaction (Butler, 1963; Wurster, 1968; Södergren, 1968).

Chlorella at a concentration of 2.54×10^7 cells $\cdot\text{ml}^{-1}$ exposed to 1 ppm of Kepone was equivalent to 0.4×10^{-7} μg Kepone in the water for each cell. While information was not found on populations of algae throughout the James River, information was available on cell populations in the Hampton Roads area and chlorophyll *a* concentrations in the James River. Marshall (1967) found that populations of algae in the Hampton Roads area were approximately 200 cells $\cdot\text{ml}^{-1}$ during the summer months. Chlorophyll *a* content in the James River ranged from less than $10 \mu\text{g}\cdot\text{l}^{-1}$ near Hampton Roads to more than $40 \mu\text{g}\cdot\text{l}^{-1}$ near Hopewell, Virginia (United States Environmental Protection Agency, 1978). Assuming cell concentration as a direct function of chlorophyll content, cell populations ranged from 200 to 800 cells $\cdot\text{ml}^{-1}$. Sampling of the James River water revealed Kepone concentrations from as high as $0.042 \mu\text{g}\cdot\text{l}^{-1}$ to less than $0.006 \mu\text{g}\cdot\text{l}^{-1}$ (United States Environmental Protection Agency, 1978). The amount of Kepone in the river water was calculated to range from 2.1×10^{-7} μg to 7.5×10^{-9} μg Kepone for each algal cell in the James River. The 0.4×10^{-7} μg Kepone in the water for each cell in these studies is within the range found under natural conditions and thus it appears that Kepone may reduce photosynthesis and probably growth of algae in the James River.

Amount of ¹⁴C-Kepone removed from solution. *Chlorella*, at concentrations of 1×10^6 , 5×10^6 , and 1×10^7 cells $\cdot\text{ml}^{-1}$ removed 13, 40 and 57% of Kepone from solution, respectively, after 30 min of incubation (Fig. 1) indicating that the removal of Kepone was dependent upon cell concentration. *Chlorella* cells showed a significant efflux of Kepone during longer incubations.

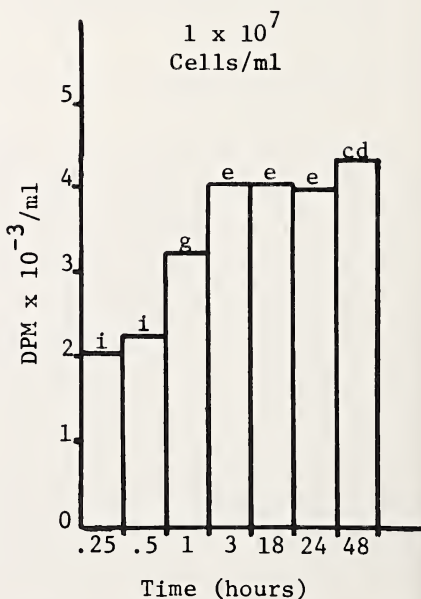
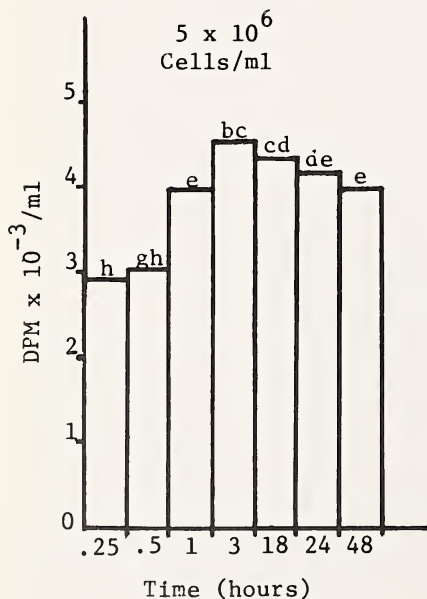
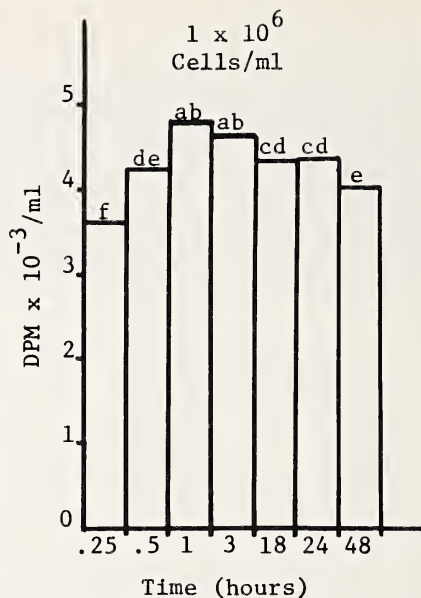
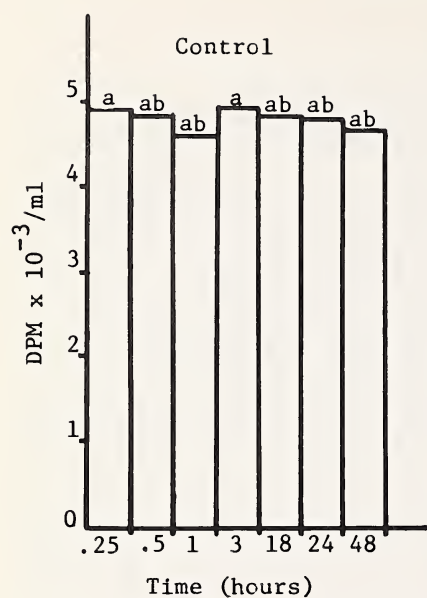


FIG. 1—Amount of ^{14}C -Kepon remaining in solution after uptake by *Chlorella* over a 48 hr sampling period. All bars with the same

letter are not significantly different at the 5% level of confidence according to the Duncan's Multiple Range Test.

The rates of efflux peaked at 1 and 3 hr incubations at the lower cell concentrations, but continued during the entire 48 hr period at the highest cell concentration. The lower cell concentrations of *Chlorella* removed Kepone from solution at a steady rate after 3 hr of incubation until the experiments were terminated. This may be related to algal growth resulting in higher cell concentrations (Fig. 2). The amount of Kepone removed in 48 hr by each of the cell concentrations, 1×10^6 , 5×10^6 , and 1×10^7 cells·ml⁻¹ was 17, 17 and 10%, respectively.

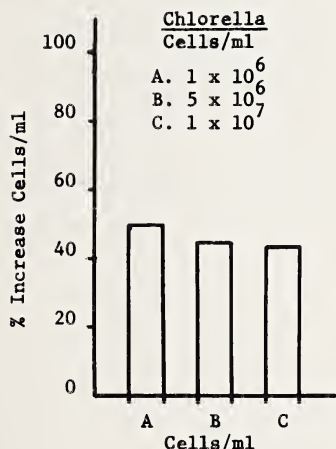


FIG. 2.—Percent increase of *Chlorella* cell number during uptake study over 48 hr.

Chlorococcum cells did not demonstrate the efflux of Kepone observed with *Chlorella* except at the 1×10^6 cells·ml⁻¹ (Fig. 3). It appears that an equilibrium of Kepone with the algal cells was reached rapidly. A trend toward continued removal of Kepone was evident in the later sampling interval; however, this may have been due to increased cell number (Fig. 4). *Chlorococcum* at 1×10^5 , 5×10^5 , and 1×10^6 cells·ml⁻¹ removed 8, 40 and 57%, respectively, of the Kepone from solution.

The reason for Kepone efflux was not completely resolved; however, equilibriums between adsorption/desorption and absorption are probably involved. Many organochlorine insecticides have adsorptive properties (Acree, 1963) and Kepone has a high affinity for organic material (United States Environmental Protection Agency, 1978). Adsorbed Kepone may be desorbed when the pH of the medium becomes more alkaline. It is not known if the pH of the medium

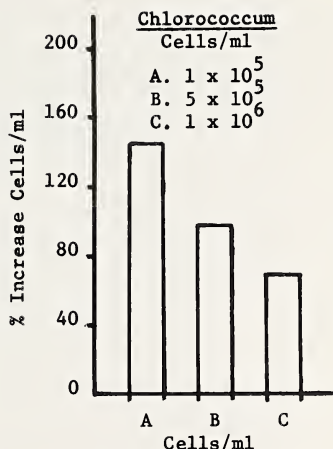


FIG. 4.—Percent increase of *Chlorococcum* cell number during uptake study over 48 hr.

changed during these incubations; however, algal cells normally do increase the pH of the medium during photosynthesis. Kepone levels in the James River water peaks at a time when algal and phytoplankton reach peak growth.

Absorption may occur actively or passively and is a physical and complex physiological process in which photosynthesis and respiration play an important role (Hill et al., 1967). Lipid-soluble materials move through cell walls and membranes. This penetration is due to lipid and water solubility of the substance with the lipid solubility determining the extent of penetration. A substance which has a higher lipid than water solubility will move from the water phase to the lipid phase (Södergren, 1968). The solubility of Kepone in water is approximately 2.0 ppm at pH 7. Its solubility in lipids is quite high, but the actual quantity is not known (United States Environmental Protection Agency, 1978). Algae are approximately 20% lipid on a dry weight basis (David M. Orcutt, Unpublished data); therefore, the rapid initial uptake plus the high lipid solubility of Kepone suggests that absorption may be quite important in Kepone uptake. Kepone inhibits photosynthesis, respiration and various enzymes and an alteration of the metabolism of *Chlorella* by Kepone may have caused the efflux of Kepone.

Efflux of Kepone. The data (Fig. 5 and Fig. 6) show that a portion of the activity associated with algal cells was not bound and was released into solution indicating that Kepone was absorbed by algal cells, affected respiration reducing energy level associated with membranes, and released back into the medium. If absorption was the only mechanism of uptake, the

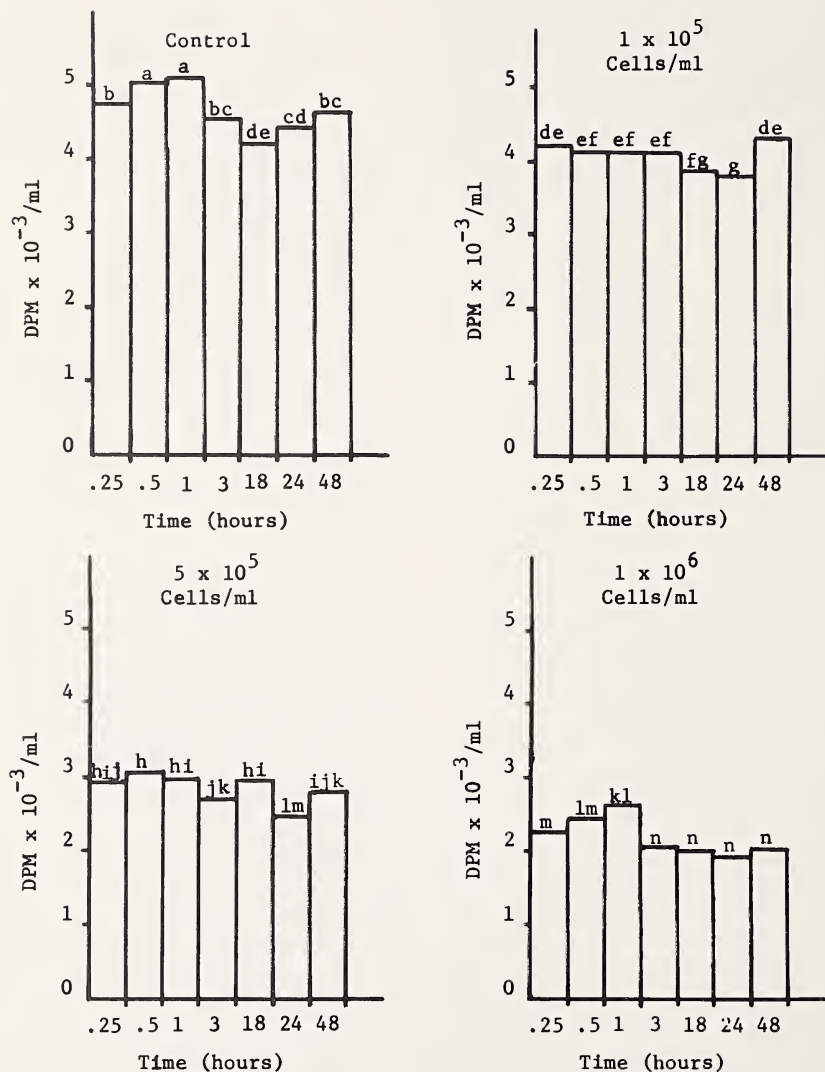


FIG. 3—Amount of ^{14}C -Kepone remaining in solution after uptake by *Chlorococcum* over a 48 hr sampling period. All bars with the same letter are not significantly different at the 5% level of confidence according to the Duncan's Multiple Range Test.

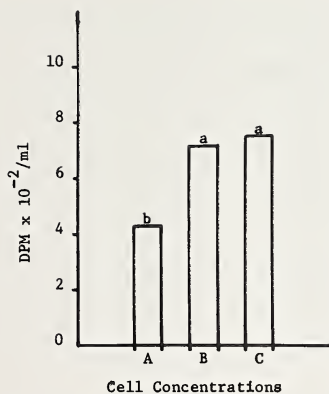


FIG. 5—Efflux of ¹⁴C-Kepone after 48 hr from *Chlorella* cells. Cell concentrations, A, B, C, refer to final cell counts, A(6 × 10⁶), B(2.85 × 10⁷), and C(5.96 × 10⁷), centrifuged from 4 ml of treatment solution and placed in 2 ml of nutrient solution without labeled material. ^{a/}Bars with the same letter are not significantly different at the 5% level of confidence.

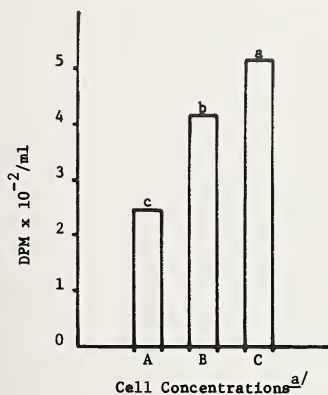


FIG. 6—Efflux of ¹⁴C-Kepone after 48 hr from *Chlorococcum* cells. Cell concentrations, A, B, C, refer to final cell counts, A(9.9 × 10⁵), B(4.0 × 10⁶), and C(6.8 × 10⁶), centrifuged from 4 ml of treatment solution and placed in 2 ml of nutrient solution without labeled material. ^{a/}Bars with the same letter are not significantly different at the 5% level of confidence.

data would have indicated more Kepone returning to solution. Since photosynthesis was occurring and the pH of the growth medium normally rises, it is also possible that some adsorbed Kepone was released back to the medium. Both absorption and adsorption appeared important in the uptake and efflux of Kepone by algae.

Algae accumulated Kepone to toxic levels from low concentrations (Walsh et al., 1977); however, the data reported here indicate that desorption occurred. Movement of Kepone contaminated algae by flowing water may release Kepone in uncontaminated areas allowing Kepone to become available to clean sediments and accumulation by aquatic organisms.

Literature Cited

- Acree, F., Jr. (1963): Insecticide volatility, codistillations of DDT with water. *J. Agric. Food Chem.* 11:278-280.
- Anderson, B. M., Kohler, S. T. and Young, R. W. (1978): Interactions of Kepone with rabbit muscle lactate dehydrogenase. *J. Agric. Food Chem.* 26:130-133.
- Anderson, B. M., Noble, C., Jr. and Gregory, E. M. (1977): Kepone inhibition of malate dehydrogenases. *J. Agric. Food Chem.* 25:485-489.
- Arnon, D. I. (1949): Copper enzymes in isolated chloroplasts. Polyphenol oxidase in *Beta vulgaris*. *Plant Physiol.* 24:1-15.
- Bahner, L. H., Wilson, A. J., Jr., Sheppard, J. M., Patrick, J. M., Jr., Goodman, L. R. and Walsh, G. E. (1977): Kepone bioconcentration, accumulation, loss and transfer through estuarine food chains. *Chesapeake Sci.* 18:299-308.
- Butler, P. A. (1963): Pesticide wildlife studies: a review of fish and wildlife investigations during 1961 and 1962. Commercial fisheries investigation pp. 11-25. J. L. George (ed). Fish and Wildlife Service Circ. 167, U.S. Dept. Int., Washington, D.C., 109 p.
- Byard, J. L., Koepke, V. C., Abraham, L., Golberg, L. and Couston, F. (1975): Biochemical changes in the livers of mice fed Mirex. *Toxicol. Appl. Pharmacol.* 33:70-77.
- de la Cruz, A. A. and Naqvi, S. M. (1973): Mirex incorporation in the environment: uptake in aquatic organisms and effects on the rates of photosynthesis and respiration. *Arch. Environ. Contam. Toxicol.* 1:255-264.
- Desai, D. and Koch, R. B. (1975): Inhibition of ATPases activity in channel catfish brain by Kepone and its reduction product. *Bull. Environ. Contam. Toxicol.* 13:153-158.
- Desai, D., Ho, I. K. and Mehendale, H. M. (1976): Effects of Kepone and Mirex on mitochondrial Mg²⁺ ATPase activity in rat liver. *Toxicol. Appl. Pharmacol.* 39:219-228.
- Desai, D., Ho, I. K. and Mehendale, H. M. (1977): Inhibition of mitochondrial Mg²⁺ ATPase activity in isolated perfused rat liver by Kepone. *Biochem. Pharmacol.* 26:1155-1159.
- Freedland, R. A. and McFarland, L. Z. (1965): The effect of various pesticides on purified glutamate dehydrogenase. *Life Sci.* 4:1735-1739.
- Hansen, D. J., Nimmo, D. R., Schimmel, S. C., Walsh, G. E. and Wilson, A. J., Jr. (1976): Kepone: Hazard to aquatic organisms. *Science* 193:528.
- Hansen, D. J., Nimmo, D. R., Schimmel, S. C., Walsh, G. E. and Wilson, A. J., Jr. (1977): Effects of Kepone on estuarine organisms. In: *Recent Advances in Fish Toxicology: A symposium*. EPA publication 600/3-77-085. pp. 20-30.
- Hill, J. B., Popp, H. W. and Grove, A. R., Jr. (1967): Botany. McGraw-Hill Book Co., New York. 633 p.
- Hollister, T. A., Walsh, G. E. and Forester, A. J. (1975): Mirex and marine unicellular algae: accumulation, population growth and oxygen evolution. *Bull. Environ. Contam. Toxicol.* 14:753-759.
- James, D. E. (1974): *Culturing Algae*. Carolina Botanical Supply, Burlington, NC. 24 p.
- Marshall, H. G. (1967): Plankton in James River Estuary, Virginia. I. Phytoplankton in Willoughby Bay and Hampton Roads. *Chesapeake Sci.* 8:90-101.

- Menzel, D. W., Anderson, J. and Randtke, A. (1970): Marine phytoplankton vary in their response to chlorinated hydrocarbons. *Science* 167:1724-1726.
- Palmer, C. M. (1962): *Algae in Water Supplies*. U.S. Dept. Health, Ed. and Welfare, Public Health Service. Pub. No. 657, Washington, D.C. 88 p.
- Pardini, R. S., Heidker, J. C. and Payne, B. (1971): The effect of some cyclodiene pesticides, benzhexachloride and toxaphene on mitochondrial electron transport. *Bull. Environ. Contam. Toxicol.* 6:436-444.
- Södergren, A. (1968): Uptake and accumulation of ^{14}C -DDT by *Chlorella* sp. (*Chlorophyceae*). *Oikos* 19:126-138.
- Sokal, R. R. and Rohlf, F. J. (1969): *Biometry*. W. H. Freeman and Company, San Francisco, CA. 776 p.
- United States Environmental Protection Agency. (1978): EPA Kepone Mitigation and Feasibility Project, Appendix A. Washington, D.C.
- Valentine, J. P. and Bingham, S. W. (1974): Influence of several algae on 2,4-D residues in water. *Weed Sci.* 22:258-363.
- Valentine, J. P. and Bingham, S. W. (1976): Influence of algae on amitrole and atrazine residues in water. *Can. J. Bot.* 54:2100-2107.
- Vance, D. and Drummond, W. (1969): Biological concentration of pesticides by algae. *J. Amer. Water Wks. Assn.* 61: 360-362.
- Walsh, G. E., Ainsworth, K. and Wilson, A. J. (1977): Toxicity and uptake of Kepone in marine unicellular algae. *Chesapeake Sci.* 18:222.
- Wurster, C. F., Jr. (1968): DDT reduces photosynthesis by marine phytoplankton. *Science* 159:1474-1475.

Gall Formation and Life History of *Pineus floccus* (Patch) (Homoptera: Adelgidae) in Virginia¹

Lucile Walton

1116 Richmond Blvd.
Danville, Virginia 24541

Abstract—In Virginia the primary host of *Pineus floccus* is *Picea rubens* and the secondary host is *Pinus strobus*. All generations reproduce parthenogenetically, and each generation has five instars.

One generation occurs each year on red spruce. This generation consists of the gallicolae or gall formers which inject cecidogen into young spruce buds which form the galls. Adults of this generation have wings and fly to white pine.

Annually there are four generations of wingless insects on white pine. A generation appears in March, late May, early July and October. Adults of the October generation overwinter on pine, and deposit eggs which develop into both wingless and winged forms. Those without wings remain on the pine, and those with wings fly to spruce and deposit eggs on young spruce buds. These eggs develop into the gallicolae.

Introduction

This article presents information on the role of *Pineus floccus* (Patch) in the development of galls on red spruce, *Picea rubens* (Sargent), its primary host in Virginia, on the life cycle of the insect on red spruce and on its secondary host, eastern white pine, *Pinus strobus* (L.), and on the presence of cecidogen in the insect and in gall tissue.

It is likely that the substance stimulating gall formation in the red spruce is cecidogen, and for convenience will be called that in this report. Earlier studies by Lewis and Walton (1958) showed that the cone gall of witch hazel, *Hamamelis virginiana* (L.), resulted from the injection of cecidogen into the plant by the aphid *Hormaphis hamamelidis* (Fitch). Later these authors (1964) stated that leaf galls on hackberry, *Celtis occidentalis* (L.), were caused by the injection of cecidogen into the leaf by a psyllid *Pachypsylla* sp. Unpublished studies (by I. Lewis and L. Walton) of galls caused by mites, midges, wasps, aphids and other arthropods demonstrated the presence of cecidogen in both insects and gall tissue.

Cecidogen occurs in amorphous masses, crystals or granules. It may change from one form to another. Cecidogen replicates in the insect, is injected into the plant and is found in vacuoles in the tissues of both. This material is virus-like, and very similar to viruses found in kataplastic galls. The crystals are diagnostic and are Feulgen-positive.

Materials and Methods

Investigations on *Pineus floccus* (Patch) began in 1963 and terminated in 1975. They were carried out in Virginia at Mountain Lake Biological Station, Giles

County, elevation 1165 m, and at Danville, Pittsylvania County, elevation 183 m.

Red spruce and white pine grow well in the Mountain Lake area, and between 1935 and 1940 about 25 spruce and 12 pines were planted on the Biological Station grounds. Fifteen more spruce were planted in the 1950's.

Each year from 1966-1974 white pines 30-60 cm high were planted in cans at Mountain Lake in June, and in early July red spruce twigs with galls were placed in bottles of water at the base of the pines. Each plant was then covered with two thicknesses of white cheese cloth supported by a frame. Winged adults emerged from the galls and deposited numerous eggs on the pines. After the eggs hatched the cheese cloth was removed and the spruce twigs were discarded. Each year the infected, potted pines were taken from Mountain Lake to Danville in late August, placed under a plum tree, and observed through the following May. Also, on June 28, 1970, one 60 cm pine was planted on the grounds at Mountain Lake Biological Station, enclosed with spruce galls under white cheese cloth and observed for the next four years.

At Mountain Lake white cheese cloth bags were placed on twigs of pines planted between 1935 and 1940 and spruce twigs with galls containing late instar nymphs were placed in the bags the first week in July. These pines were observed regularly in late July and August, infrequently in October, April and early May. In late May the bags were removed and the pine twigs marked for further observation. Experiments with older pines were conducted from 1965 through 1975. During these years, late in June, infested small twigs of pine and spruce were brought into the laboratory, placed in bottles of water and covered with a beaker. These were observed regularly until late August to determine the number of days required for egg laying, hatching and molting.

Observations were made on insects which developed from eggs laid by adults that over-wintered on the pine. Early in June 1971, infected twigs from the pine tree planted at Mountain Lake in 1970 were brought into the laboratory and placed in water. Winged adults were removed from the pine and placed singly in Petri dishes on damp filter paper with young

¹Research conducted at Mountain Lake Biological Station and author's home address.

spruce buds, and their behavior was observed.

Permanent mounts were made of both whole insects of all generations and of dissected adults. They were killed in formalin-acetic acid-alcohol (100 cc—50% C_2H_5OH , 6 1/2 cc 40% $HCHO$ and 2 1/2 cc glacial CH_3COOH), dehydrated through a series of alcohols, cleared in clove oil, xylol, and mounted in Canada balsam. The best whole mounts were obtained by fixing and embedding in paraffin, dissolving the paraffin in xylol and clearing in clove oil.

The Gall

The red spruce gall is a terminal or lateral bud gall, and is commonly known as a pineapple gall because of its internal and external resemblance to that fruit. It is protoplasm with a definite morphological pattern.

Red spruce needles are borne on short stalklets whose cells are cortical in nature and an outward extension of the shoot. Between the first mesophyll cells and the stalklets is the intercalary meristem which causes needles to increase in length. As development takes place the abscission layer is formed, comprising a transverse layer two or three cells thick. These cells are at the distal end of the stalklet. A detailed account of the anatomy of fully developed spruce needles was given by Marco (1939).

In the spring winged insects fly from white pine to spruce and oviposit on the swelling buds. The nymphs which develop from these eggs inject cecidogen into the bud between the acute angle at the upper part of the stalklet and the shoot. The cecidogen injected into the plant causes divisions in the epidermal cells and the formation of trichomes. The growth of the gall is due to hypertrophy and hyperplasia of the cortical cells of the shoot and stalklets. The nymphs are located and maintain themselves in original cavities formed by narrowed needle bases in the normal shoot. The great radial growth of the shoot pushes the cavities with the insects outward from the central cylinder. Because the gall is formed by an outward proliferation of cortical cells, a partition forms between chambers. Lateral growth of stalklets forms "flaps" which cover the cavity and are irregularly triangular in shape. Their formation is caused by the position of the stalklets on the shoot. In red spruce the needles are arranged in a rising spiral. Any one chamber of the gall is bounded laterally above and below by two other chambers. There is little growth on the side next to the shoot. Cecidogen moves outward in all directions from the point of injection but its distribution is limited as shown by Meyer (1962). It moves through the cortical cells to the shoot and to the surrounding needle stalklets, causing cell divisions in both. Cecidogen can pass through the stalklet abscission layer and into a few cells of the needle. In most galls it does not reach the meristematic tissue of the needle. Needles of galls are only slightly shorter than normal, and since the abscission layer does not develop normally the needles never drop from the galls. Old galls resemble small cones and remain on the tree for several years.

Although most of the growth of the gall is lateral, there is some increase in length. At the time the gall is initiated the bud is less than 1 cm in length, but all galls become larger than this, and some near the top of young trees may reach a length of 10 cm. Galls on red spruce develop in a similar manner to those described on Norway spruce by Plumb (1953), but most galls on red spruce are symmetrical. Nymphs settle on all sides of the bud usually at the base of each needle in the central part of the gall, fewer at its base and apex. A cross section through the center of a gall in June showed six cavities, and a longitudinal section of the same gall showed eight cavities. The cavities are not connected. More nymphs were found in the central cavities.

Although it is difficult to distinguish a very young gall from a bud, the young gall is harder and has more trichomes on the stalklets than the typical bud. Yellow color appears at the base of the needles of the gall and then a great increase in thickness quickly differentiates the two. Late in June red color appears around the outer edge of the "flaps". It is first seen on the side of the gall which is toward the sun, on the south side of the tree. This is where the first openings between the gall "flaps" occur and where the winged females emerge. When the galls open, the tissues begin to deteriorate. As the insects come out, outer tissues become brownish and the discoloration extends inward. Exposure to air, thus drying out, must have something to do with this. The needles remain alive until the cavities open. Fibrovascular bundles are close to the bottom of the cavity. Decay sets in here, and in a few days after the galls open, the needles turn brown.

The gall is formed from a bud that would normally develop into a twig with terminal and lateral buds. If cecidogen does not reach the buds of the gall, the buds will develop the next year. After several years the old galls, from which the twigs developed, may still be located by the thickness of the stem.

Location and Variation in Number of Galls on Red Spruce—Most galls on older trees were found near the top, but on young ones were all over. In the forest as many as 20 galls were found on a 25 cm seedling. The number of galls on a tree varied from year to year. Studies were made on a 91.4 cm spruce planted in 1955. For several years after it was planted it was covered with galls and looked as though it would die. It was still heavily infested in 1964 and was only 1.5 m tall. In 1965 it started growing faster, and by 1975 it had reached a height of 4.57 m. Galls on this tree counted each year from 1965 through 1975, numbered 5 in 1965, 0 in 1966, 1,470 in 1967, 700 in 1968, 232 in 1969, 70 in 1970, 6 in 1971, 300 in 1972, 80 in 1973, 1,096 in 1974 and 117 in 1975. From 1965 to 1975 all spruce in the Mountain Lake area showed similar variation in the number of galls.

The variation in number of galls might be explained in part by the fact that there are wingless insects which remain on the pine and produce winged insects which fly to the spruce in the spring. Also weather conditions

influence the population of gall forming insects. Although the temperature at Mountain Lake may fall to -31.7°C the insects survive as the generation which overwinters on the pine has denser chitin and body fluids than other generations. Low temperatures kill the next generation. A severe cold spell in May 1965 killed all vegetation and probably the developing insects as there were few galls that year.

At Mountain Lake, in the spring of 1971, there was an ice storm which lasted several days and the temperature dropped to -5°C . Winged and wingless nymphs can survive this temperature but few galls were found that year. Nymphs probably died from lack of oxygen. Pine twigs placed in bags in 1970 showed many dead nymphs which normally would have developed in the spring. The pine infected at the same time as the bagged ones and taken to Danville had many living winged and wingless insects in the spring of 1971.

Life History of the Insect

In *Pineus floccus* all generations reproduce parthenogenetically (see diagram). Yearly there is one generation on red spruce and four on white pine. The adults (gallicolae) of the generation on red spruce are winged and fly to the pine. Adults of generations on white pine are wingless except those that develop from eggs laid in March. All insects which overwinter on the pine produce both wingless (progreddiens aptera) and winged forms (progreddiens alata), and the latter fly to the spruce. Each generation has five instars.

Generation on Red Spruce: Gallicolae or Gall Formers—Alatae fly from pine to red spruce in May. At this time spruce buds begin to grow and pull bud scales away from the base of the bud. The winged forms enter the bud through this space and deposit eggs, usually on the inner side of the needles. As many as ten adults may oviposit in one bud. The eggs develop into the gallicolae or gall formers. In the laboratory the eggs hatch in ten days after deposition. The young nymphs insert their stylets at the base of a needle and as many as five may select the same needle, and are covered by gall tissue. Because the nymphs are concealed, their development cannot be observed. Between the arrival of winged adults on the spruce and the next generation of winged adults, five to six weeks elapse.

Winged adults leave the galls at varying times of the year—July 10 in 1963, 1964, 1967, 1973 and 1975; and July 15 in 1965, 1966, 1968, 1971, 1972 and 1976; and July 1 in 1969 and 1970. Winged forms leave the same gall at different times because all gallicolae in a gall are not in the same instar at the same time.

In a gall 4.5 cm long and 2.0 cm wide, 470 nymphs were found. Most were young Instar 5, some 4 and a few 3. Instars 3 and 4 were found either near the apex or base of the gall. The count was made in late June before the galls opened.

Soon after winged adults are formed, the "flaps" of the galls separate, and insects emerge, carrying wax and exuviae with them. After this, predators and other arthropods, especially mites, move into the cavities.

Generation on white pine—After leaving the spruce galls, the insects fly around for a day or two, then move to the white pine, settle on needles of the present or previous year's growth and start ovipositing, usually on the upper surface of needles. Several females may lay eggs on the same needle and their heads may point either toward the needle's apex or base. Adults remain over empty eggs after the eggs have hatched. After egg laying was completed, pine needles were collected and the eggs counted. The largest insects laid as many as 160, and the smaller ones 60, but most produced 80 eggs.

In the laboratory unfested twigs of white pine were placed in water under a beaker with red spruce galls containing winged adults. Most of the winged insects emerged from the galls about 2:00 p.m., walked for some time and then began to fly. They were attracted to light. They flew for a day or two, then settled on a pine needle and after 12 to 24 hours started ovipositing. They continued egg laying for two or three days and lived one day after completing oviposition. As the eggs were deposited the female moved forward. The eggs at the greatest distance from the female hatched first, in 7 to 10 days. The nymphs walked down the needles to the stem, went either up or down the stem, and inserted their stylets at the base of a bundle of pine needles or under a scale on the stem.

In this discussion the first generation of insects that developed on pines taken to Danville, and those at Mountain Lake which had been bagged with galls, are referred to as Generation I (See Diagram). The first 3 instars of Generation I were reared in the laboratory. The first molt took place 7 to 10 days after hatching and the second 10 to 14 days later. On living trees time to first molt was 3 or 4 days, depending on the temperature. Later molts were not followed as Mountain Lake Biological Station closes about August 20. However, return trips in early October indicated that adults of Generation I, instar 5, began laying eggs at Mountain Lake then and later in the month at Danville. These eggs give rise to Generation II. In Danville all instars of this generation were present the first week in November and all were adults by the first of December. These adults spent the winter at the base of pine buds, needle bundles or stem scales.

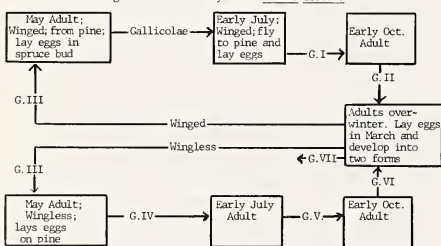
The time of oviposition of Generation II seems dependent on temperature as it is colder at Mountain Lake than at Danville. In Danville females laid eggs as early as March 8 and as late as the end of March. At Mountain Lake most adults deposited their eggs in late April or early May. Developmental stages of *Pineus floccus* on pine from Mountain Lake and Danville were compared on April 21, 1973. At Mountain Lake only adults of Generation II were found and no wax was present, while in Danville the first three instars of Generation III and alatae had developed.

Eggs laid by adults of Generation II numbered 40 to 60, and usually hatched in 10 days, but it took about 3 days longer in cold weather. Apteroous adults of Generation II, young nymphs of Generation III and alatae were attracted to the developing white pine buds and

many moved from the place where they spent the winter or where the eggs hatched. At the time the transparent scales were still on the pine buds but had separated at the apex forming openings. Nymphs entered the buds through these openings. Instars 1, 2, and 3 could be seen through these scales and as the scales fell off more nymphs moved to the developing buds.

The eggs of Generation II which overwintered on the pine, developed into two forms, apterae, wingless Generation III, which remained on pine, and alatae, which flew to the spruce. No differences were evident in these two forms in Instars I and 2, but in Instar 3 wing pads were visible in some individuals. The insects which showed no wing pads in Instar 3 were similar to and followed the same pattern of development as all generations on the pine. Those which developed wing pads in Instar 3 followed the same development pattern as similar stages of gallicolae. Both forms matured in May. Winged GIII flew to spruce and deposited eggs in the buds which produced the gallicolae. Wingless GIII laid eggs on pine and formed GIV. In early July winged gallicolae flew back to pine, deposited eggs which became GI. At the same time GIV laid eggs resulting in GV. Both GI and GV laid eggs in early October and produced GII and GVI. These two generations were adults in December and overwintered on white pine. In March, both laid eggs which developed into winged and wingless insects. The winged from both generations flew to spruce and GIII and GVII remained on pine (See Diagram).

Diagram of the Life-Cycle of *Pineus flocuosus*



G = Generation

Note - The only generation on the spruce are the gallicolae. All others are on the pine. Generations II and VI produce two forms, winged which fly to the spruce and wingless which remain on the pine and produce G.III and G.VII.

All nymphs were removed from a pine bud in May, of 30 examples representing Instar 3 and 4, 28 had wing pads, while 12 nymphs removed from the base of a needle bundle on the same twig showed only one with developing wing pads.

To observe if there were differences between Generations V and I, pine twigs with instars of Generation IV were brought into the laboratory late in June. The twigs were placed in water, eggs were deposited the first week in July and the resulting nymphs observed. No differences were found between these insects and those of Generation I.

In any one generation there may be several weeks difference in the time the adults appear. Generally, eggs for the next generation are laid in March, late May, early July and October. A white pine planted and infected with *Pineus flocuosus* at Mountain Lake in 1966 was carried to Danville in late August, the same year, and lived through the spring of 1973. During this entire time 273 instars of wingless forms were produced, while 7 generations, one per year, of alatae developed.

Description of the Insects

Mouth organs of all nymphs of all generations are similar. The stylet is needle-like and consists of two pairs of chitinous sheaths, one maxillary, the other pair mandibular. The maxillary pair is firmly interlocked and appears as a single structure. It contains two minute tubes formed by opposing grooves. The dorsal or food canal connects with the pharyngeal pump. The ventral one joins the salivary syringe and is used for the ejection of saliva from the salivary glands. When extended the mandibular sheaths are closely applied to the mandibular pair but are dislodged when the insect is disturbed. In slide mounted specimens three sheaths are visible, one of which is actually a pair of maxillary, the other two single mandibular. When the stylet is not extended the sheaths are coiled in each half of the head.

Gallicolae or Gall Formers on Red Spruce (Numbers are from prepared slides)

Instar 1: Nymphs emerging from eggs laid by alatae are rounded at both ends and have parallel body margins, but as they age the posterior end becomes pointed. The body and appendages are amber in color. Measurements of nymphs are based on a sample of about 15. Nymphs are 0.29-0.32 mm long and 0.17-0.19 mm wide. The ocelli have two facets and are black. The length of the stylet is 0.75 mm and the antennae 0.08 mm. The distal segment of the three-segmented antennae is longest, serrate and constricted ventrally at its proximal end which is rounded.

Instar 2: The body shape is like that of a mature nymph of Instar 1, and it is amber in color. Legs and antennae are dark gray and the 2-faceted ocelli, black. Nymphs are 0.37-0.41 mm long and 0.19-0.21 mm wide. The stylets are 0.97 mm long and the antennae 0.098 mm. Antennae of Instars 1 and 2 are similar.

Instar 3: The cephalothoracic region of nymphs is narrower than the abdomen. They are light reddish brown with dark gray legs and antennae. The nymphs are 0.45-0.6 mm long and 0.29-0.34 mm wide. The stylets are 1.0 mm long and the antennae 0.12 mm. Serrations begin to disappear on the last segment of the antennae. Wax pores appear in this instar. Soon after molting, wax emerges from pores on the head, then the thorax, and still later from the abdomen. The pores are arranged in five longitudinal rows except the head and posterior end of abdomen. Wing pads begin to appear in this stage.

Instar 4: Nymphs are red brown in color with dark appendages, and are much larger than the previous instar, 0.75-1.35 mm long and 0.56-0.64 mm wide. A freshly molted nymph shows only one pair of lateral ocelli, and as it ages compound eyes appear anterior to the ocelli, and three more ocelli become evident at the top of the head. The stylets are 1.2 mm long and the antennae 0.25 mm. Internally the terminal segment of the antennae shows three divisions. Wax pores are prominent, there are four on the head, six on each segment of the thorax, and six on each segment of the abdomen except the last which has four. The pores are arranged in longitudinal rows. Wing pads are prominent.

Instar 5 (Winged Migrants [Gallicolae] to the White Pine): Freshly molted individuals have bright brown head and thorax with amber wings. In older ones the head, thorax, legs and antennae are black, with amber abdomen and wings. Lateral ocelli persist through the life of the insect, are larger than facets of the compound eyes and protrude laterally beyond the lower part of the compound eyes. Dorsally between the compound eyes are three small ocelli. These are large and small winged forms, 0.875-1.95 mm long and wing span 3.8-5.9 mm. According to Patch (1909), "the wings are rather narrow, 1st A in the forewing curves, the concavity being distad. M of the hind wing curves, the concavity being distad." The stylets of this adult are 0.9 mm long. Antennae are 0.3 mm long and were described by Patch (1909) as follows: "The antennae are characterized by exceedingly large sensoria on joints III, IV, V. Each sensorium comprises the entire surface of the joint except proximal and distal portions and a narrow ridge connecting these. The constrictions between joints are abrupt; III and IV are subequal and V is longer and not as thick."

Patch (1909) also described the wax pores as follows: "Large wax gland areas occur on the head of three thoracic segments. On the abdomen lateral groups are present on perfectly distinct darkened areas on segments I-VII, IV, V, and VI are transversely banded by wax pores across the dorsum. Merged medium groups occur on I, II and III and on III a separate group (sometimes absent) midway between the median and lateral groups."

Generations on White Pine

Instar 1: The amber nymphs are oval when first hatched but later become pointed at the posterior end. They are 0.26-0.33 mm long and 0.15-0.18 mm wide. Two ocelli have three facets each. The stylets are 0.56 mm long. The antennae, .075 mm long and similar to those of *Instar 1 gallicolae* on red spruce.

Instar 2: The amber nymphs are pointed at the posterior end. Most are 0.33-0.38 mm long and 0.16-0.2 mm wide but some are much larger. The two ocelli have three facets. The stylets are 0.56 mm long and the antennae 0.09 mm and as in *I gallicolae*. Wax pores appear on the head.

Instar 3: When first molted the nymphs are much wider toward the anterior end of the body but as they get older the posterior end expands. They are dark amber and the head is almost black. Nymphs are 0.39-0.41 mm long and 0.22-0.26 mm across the thorax. The ocelli are less prominent than in the first two instars and have three facets. The stylet is 0.7 mm long and the antennae 0.08 mm. There is a reduction in length and diameter of the faintly serrate terminal segment of the antenna. This segment is the same length as the other two segments and has a deep indentation near the proximal end. Large wax pores are present on the upper part of the head and the dark coloration of the area is due to the thickness of the chitin around these pores. Smaller pores are found on the thorax but not on the abdomen.

Instar 4: Nymphs are oval in shape, the head and thorax are dark and the rest of the body is amber. Nymphs are 0.6-0.75 mm long and 0.45-0.6 mm wide. Ocelli have two indistinct facets. The stylets are 1.1 mm long and the antennae 0.04 mm. The wax pores on the head and thorax are arranged in groups with single pores scattered in between. There are five large anterior groups and six smaller posterior groups on the dorsum of the head. Each segment of the thorax has a pair of lateral pores and six submedian ones. All pores differ in size from prothorax to metathorax. Each segment of the abdomen, except the last, has a pair of lateral pores, which decrease in number of facets toward the posterior end. The group of median pores are larger on the anterior segments.

Instar 5 (Wingless Adults which Remain on White Pines): The adult is almost circular with a pointed posterior end and it is dark brown or gray in color. The dorsal surface is larger than the ventral and the legs do not extend beyond the body. The insect is 0.6-0.75 mm long and 0.45-0.6 mm wide. The ocelli have only one facet. The stylets are 1.5 mm long and the antennae 0.02 mm. The third terminal segment of the antennae is shorter than the other two. The wax pores of the adult are arranged as in *Instar 4*. Only *Instar 5* of this generation secretes wax. It appears as rods first on the head, a little later on the thorax and finally on the abdomen. As the rods increase in length they separate into fluffy filaments. Most of the wax is formed in the anterior region of the head. Secretion of wax begins before egg laying.

Insects Which Overwinter on Pine—All instars of the four generations of wingless insects which occur on the white pine have similar characteristics and life histories. However the insects which overwinter on the pine are slightly larger and wax pores appear in *Instar 1*. The eggs develop two forms, wingless and winged. Winged forms beginning with *Instar 3* follow the same development pattern as similar stages of *gallicolae*. Antennae, simple and compound eyes and wax pores were like those of *Instars 3, 4, and 5* in the galls. They were smaller, 0.6-0.92 mm long, with the wing span of 2.5-3.6 mm. Winged adults produced fewer eggs than adult *gallicolae*.

Prevention and Control of Galls on Ornamental Red Spruce in Virginia

1. Do not plant red spruce and white pines in the same locality.
2. Remove and destroy all galls on the spruce in June before the winged insects emerge.
3. Contact sprays may be useless because:
 - a. The time in May when the winged forms fly from pine to spruce varies from year to year depending on the temperatures.
 - b. There may be several weeks difference between the time when the first and last winged insects reach the spruce.
 - c. Winged insects go under the scales of young spruce buds and are protected from contact poisons.

Acknowledgments

I thank Dr. Michael Kosztarab of the Department of Entomology, Virginia Polytechnic Institute and State University, for reading the manuscript and for valuable criticism; Ms. Louise M. Russell, Systematic Entomology Laboratory, ARS 11B11, U.S. Dept. of

Agriculture, for the identification of *Pineus floccus* and for her review of the manuscript; and the University of Virginia Mountain Lake Biological Station, for the opportunity to conduct this research at the Station and for assisting financially with the printing cost of this publication.

Literature Cited

- Lewis, I. F. and Walton, L., 1958. Gall-formation on *Hamamelis virginiana* Resulting from Material Injected by the Aphid *Homaphys hamamelidis*. Trans. Amer. Microsc. Soc. 77(2): 146-200.
- Lewis, I. F. and Walton, L., 1964. Gall Formation on Leaves of *Celtis occidentalis* L. Resulting from Material Injected by *Pachypsylla* sp. Ibid. 33(1): 62-78.
- Marco, H. F., 1939. The Anatomy of Spruce Needles. Agr. Res. 58(5): 357-368.
- Meyer, J., 1962. Croissance Labiale et Limites Cécidogènes de la Galle d'*Adelges abietis* Kalt. sur *Picea excelsa* Lam: Notion de Seuil d'Action Cécidogène. Marcellia. L'Institut de Botanique de Strasbourg. 224-235.
- Patch, E. M., 1909. Chermes of Maine Conifers. Maine Agr. Exper. Sta. Bull. 173: 277-308.
- Plumb, G. H., 1953. The Formation and Development of the Norway Spruce Gall Caused by *Adelges abietis* L. Conn. Agr. Exper. Sta. Bull. 566: 1-77.

Phytoplankton Studies Within the Virginia Barrier Islands

I. Seasonal Study of Phytoplankton in Goose Lake, Parramore Island

Harold G. Marshall

Department of Biological Sciences
Old Dominion University
Norfolk, Virginia 23508

Abstract—The phytoplankton of Goose Lake, an oligohaline lake on Parramore Island, was studied for one year. The populations consisted primarily of ultraplankton and nanoplankton sized forms with diatoms and chlorophyceans dominant most of the year. A general pattern of seasonally higher cell concentrations in early summer and fall was noted, with an unidentified ultraplankton sized component prominent throughout the collection period. A list of 154 species is given.

Introduction

Parramore Island is located on the eastern shore of the Delmarva Peninsula in Accomack County, Virginia. It is part of the barrier island complex under the management of The Nature Conservancy and is located approximately 50 km northeast of the Chesapeake Bay entrance (37°32' N. Lat., 75°37' W. Long.). Parramore Island is approximately 13.3 by 3 km in size, with its long axis in a general northeast direction. The Island's eastern shoreline is bordered by a parallel series of relict dunes that extend to the island's interior, with elevations up to seven m and a well-developed floral cover. The island topography decreases in elevation along the southern and western margin where the vegetation blends into an extensive salt marsh. Goose Lake has formed between two of these relict dune lines, is finger-shaped and up to 1.5 m in depth, with an area of approximately 0.07km². The size varies with seasonal periods of heavy rain, and the occasional inundation of seawater through the southern end. To the south an earlier channel to Swash Bay and the numerous tidal guts of the bordering marsh have been blocked due to vegetational growth and the accumulation of autochthonous material. During flood periods from storm tides, saltwater entry may occur at this end of Goose Lake. The lake substrate consists of a mixture of silt, sand, detrital material, and various inorganic substances. It is black in color, soft in texture, and its anaerobic state is indicated by the hydrogen sulfide odor common to the bottom samples. More detrital material is found along the shoreline, where a variety of marginal wetland plants are established. A common submergent is *Ruppia maritima*.

Several previous phytoplankton studies have been conducted in the general area of the Barrier Islands. Nearshore phytoplankton, in the vicinity of Assateague Island, was studied by Marshall and Bowker

(1976) regarding the composition and concentration of cells in relation to chlorophyll values. Their samples were dominated by several species of diatoms and the dinoflagellate *Ceratium tripos*, with the diatoms representing 55% of the composition at the station nearest Assateague Island. In a seasonal study of the phytoplankton within the channels of the Barrier Island complex, Marshall, Nesius and Cibik (1980) found *Skeletonema costatum* the dominant species throughout the year. They noted the most common species in these channels were similar to the dominant phytoplankters in the continental shelf waters. A list of summer chlorophyceans and cyanophyceans from Accomack and Northampton Counties was made by Nemeth (1969), but none of his stations were on any of the Barrier Islands. His study emphasized fresh water sites and he recorded 102 chlorophyceans, 43 cyanophyceans, and 15 other species.

Methods

Goose Lake is centrally divided into a northern and southern half by an earthen mound constructed for the placement of a road across the island. Free flow between the 2 halves of the lake takes place through a culvert approximately 0.3 m in diameter placed at basin level. During each of the eight collection trips between October 1978 and October 1979, samples were taken from two stations located in each half of the lake. These surface water samples (500 ml) were preserved immediately with a buffered formalin solution. A settling and siphoning procedure was followed to obtain a 20-ml concentrate which was subsequently examined in a settling chamber with a Zeiss Inverted Plankton Microscope. Salinity readings were taken with a portable Beckman salinometer. The classification used in this report is based mainly on the revisions by Hendey (1974) and Parke and Dixon (1976).

Results and Discussion

Goose Lake is considered an oligohaline lake with generally low saline values ($<5^0/_{\infty}$). Readings throughout the lake for the collection period indicated rather consistent salinities between 2 and $3^0/_{\infty}$. Occasionally, storm tide entry will occur from the southern end of

Goose Lake. Such an event was noted by Dr. James Matta of Old Dominion University on 25 October 1978. He took salinity readings at that time that indicated average values of $20^{0}/_{\infty}$ in both the southern and northern sections of the lake. By 26 January 1979 the average salinity value for the entire lake had decreased to $2.5^{0}/_{\infty}$, where it remained at approximately that level into October 1980, with only slight variations between both sections.

A total of 154 phytoplankters was identified within the samples. The breakdown of species for the various taxonomic groups was as follows: Bacillariophyceae (61), Euglenophyceae (22), Cyanophyceae (18), Dinophyceae (8), Chlorophyceae (21), Cryptophyceae (2), Xanthophyceae (5), Haptophyceae (2), Prasinophyceae (2), Rhodophyceae (1), and one vascular plant *Lemna minor*. The phytoplankton community was dominated throughout the year by various diatoms and chlorophyceans, with various cyanophyceans prominent (see Table 1). Seasonally there were early summer and fall maxima of numbers, with later summer and winter minima. Lowest concentrations occurred during winter (Figure 1).

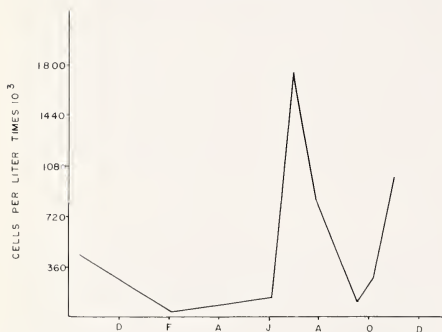


FIG. 1—Average seasonal concentrations of phytoplankton in Goose Lake from October 1978 through October 1979.

The winter phytoplankton possessed two diverse size groups of diatoms. The large cells of *Sirirella striatula* and *Tropidoneis lepidoptera* were very common in all the samples with the more abundant smaller diatoms, such as *Navicula salinarum*, *Amphora coffeaeiformis*, *Navicula* sp., *Navicula maculata*, and *Nitzschia vermicularis*. *Nannochloris atomus* was also dominant with several cyanophyceans (*Anacystis marina*, *A. dimidiata*, *Oscillatoria submembranacea*), and the chlorophycean, *Chlorella vulgaris*, common in all samples. Lowest concentrations for the collection period were noted on 2 February 1979 when average cell counts were 67,240 cells/l. One of the dominant species during this period was unidentified, but under light microscopy resembled oocystaceans previously

described in the literature (Bourrelly, 1966; Simpson and Van Valkenburg, 1978). This species was round, 4-5 μ m in size, occurring often in groups of four, with what appeared as a "rough" and thickened outer wall.

The spring samples and the early summer bloom consisted mainly of several Pennales diatoms that were less than 30 μ m in length and several small Centrales forms. *Navicula* sp., *Navicula arvensis*, *Epithemia argus*, *Stauroneis anceps* and *Nitzschia amphibia* were found in high concentrations. *Cyclotella meneghiniana* and *C. caspia* were also prominent. Other conspicuous species included *Euglena ehrenbergii*, *Nannochloris atomus*, and *Kirchneriella lunaris*. High concentrations of green round to irregularly shaped forms, 1.2 to 2.5 μ m in size, were in all the spring samples, plus an unidentified Centrales diatom with an average diameter of 3.6 μ m. The unidentified 1.5 to 2.5 sized "cells" were not included in the cell counts, but easily would have surpassed the other taxa in number. The early summer bloom continued into July with nanoplankton diatoms still dominant. However, the dominant phytoplankton assemblage was diverse in composition. *Chaetoceros debilis*, *Sirirella striatula*, *Cyclotella striata*, *Navicula arvensis*, *Rhabdonema minutum*, and the unknown Centrales (*Cylindropyx profunda*?) were abundant. Phytoflagellates included *Trachelomonas hispida*, *T. volvocina* var. *puncta*, *Gymnodinium danicans*, and *Phacus longicauda*. There were high concentrations of *Anacystis marina*, *A. montana minor*, and *A. thermalis*. An unidentified *Scenedesmus* sp. was also abundant with *Nannochloris atomus*, *Tetraedrom muticum*, and *Kirchneriella lunaris*. The highest concentrations of the study occurred at this time with 1.78 million cells/l recorded on 27 June 1978. During this period there were large concentrations of *Euteromorpha intestinales* common in the benthos in both sections of the lake. The broken fronds of this alga were floating at the surface and part of the phytoplankton community.

The phytoplankton in late summer was dominated by an early bloom of *Cyclotella striata* and *Cyclotella caspia*, with *C. caspia* retaining high concentrations into fall. A mixture of these and other small sized diatoms (< 30 μ m) and blue green algae (*Anacystis montana*, *Nostoc commune*, *Oscillatoria submembranacea*) dominated the late summer flora. Several *Oedogonium* species were present, with *Lemna minor* (common duckweed) found in high concentrations at the surface in the southern section of Goose Lake. The lowest concentrations for summer were noted in late September with *Cyclotella caspia*, *C. striata*, and *Nitzschia communis* var. *hyalina* the dominant species.

The early fall period was accompanied by a sharp rise in the nanoplankters, with chlorophyceans, diatoms, and phytoflagellates abundant. The diatoms consisted of mainly *Rhabdonema minutum*, *Nitzschia closterium*, *Cocconeis pendiculus*, *Nitzschia* sp., and *Cyclotella* spp.. The major flagellates were *Chrysococcus minuta*, and *Cryptomonas* spp., with the green algae *Nannochloris atomus*, *Chlorella ellipsoidea* and *Chlorella vulgaris* also numerous. Of interest was the

presence of several *Euglena* species, mainly composed of *Euglena agilis*, *Euglena pumila*, and *Euglena ehrenbergii*. In addition, *Phacus* sp. #1 was also common. This seasonal bloom was distinct but smaller in magnitude in comparison to the early summer bloom.

The productivity pattern resulting from phytoplankton growth for the period of study was peak development during early summer (where average counts reached 1.7 million cells per liter on 29 June 1979). A marked reduction followed with a second surge of growth in fall reaching 0.9 million cells per liter on 29 October 1979 (Table 2). The pattern from fall 1978 was a gradual decline into winter, where lowest values occurred in February (67,240 cells/l).

Table 2.
Average cell counts for phytoplankton at stations in the southern and northern sections of Goose Lake during the collection period. Numbers represent cells/liter.

Date	South Section	North Section	Average
13 Oct 78	364,520	539,480	452,000
2 Feb 79	46,600	87,880	67,240
3 Jun 79	174,850	135,330	155,090
29 Jun 79	1,788,800	1,682,400	1,735,600
27 Jul 79	506,480	981,920	744,200
17 Sep 79	142,640	160,280	151,460
1 Oct 79	210,080	432,640	321,360
29 Oct 79	1,029,660	773,760	901,710

The nanoplankton composition has been generally defined by Strickland (1960) as having a size range of 10 to 50 μm , with those forms having sizes between 0.5 to 10 μm as belonging to the ultraplankton. Using this classification, the major phytoplankton components in Goose Lake were the ultraplankton with another major group consisting of nanoplankters in the 10- to 20- μm size category. The more abundant ultraplankton were the diatoms *Cyclotella caspia*, *Navicula ato-*

mus, and an unknown Centrales diatom; the cyanophyceans *Anacystis marina*, *A. montana minor*, *A. thermalis*; the chlorophyceans *Chlorella vulgaris* and *Nannochloris atomus*; the chrysophyceans *Chrysococcus minutus*, *Ochromonas variabilis*, *O. miniscula*; the euglenophycean *Trachelomonas volvocina* var. *puncta*; and the xanthophycean *Monodus guttula*. Still not fully addressed are unidentified ultraplankton less than 2.5 µm in size, that were common throughout the year. Further study of this component of the plankton community is needed to more fully ascertain their role in productivity and contribution to various lentic food chains. The dominant nanoplankton were *Cyclotella* spp., and a variety of Pennales forms. Of note were *Rhabdonema minutum*, *Amphora coffeaeiformis*, *Cocconeis* sp., and *Nitzschia closterium*. The nanoplankton phytoflagellates were represented by *Cryptomonas* spp., *Trachelomonas* spp., and *Nephrochloris salina*.

The seasonal populations at Goose Lake represented combinations of what are considered typical marine and fresh water species throughout the year with fewer of the more common fresh water species found in winter. These results differ from composition studies made in the channels of the Barrier Islands and the coastal waters where marine diatoms dominated (Marshall, et al., 1980; Marshall and Bowker, 1976). However, the unidentified ultraplankton component noted in Goose Lake was similar to what Marshall, et al. (1980) reported within the Barrier Island channels. Different population assemblages were also present within the chlorophycean, cyanophycean, and euglenophycean groups in Goose Lake in comparison to those noted on the nearby mainland by Nemeth (1969).

Acknowledgements

Appreciation is given to Virginia Environmental Endowment for supporting this study under Grant 78-02. Further thanks is given to Dr. James F. Matta and Mr. James Cowan for assistance during the collection trips to Paramore Island.

Table 1. Phytoplankton identified in Goshute Lake. Seasonal presence is noted with X; the more dominant species are indicated by A, B, C, with A being most abundant.

	W	S	G	F
<u>Acillariophyceae</u>				
<i>Amphora</i> sp.	-	X	-	-
<i>Amphora coffeae</i> Formis Kutzing	A	X	-	X
<i>Amphora ovalis</i> (Kutzing) Kutzing	A	-	-	X
<i>Arctutia insecta</i> (Grunow) Cleve	X	-	X	-
<i>Caloneis weevil</i> (Smith) Hendey	-	-	-	X
<i>Chaetoceros</i> sp.	-	-	X	X
<i>Chaetoceros compressus</i> Lauder	-	-	X	X
<i>Chaetoceros baillii</i> Cleve	-	-	X	X
<i>Coconeis</i> sp.	-	-	X	X
<i>Coconeis penicillatus</i> Ehrenberg	-	-	-	B
<i>Coscinodiscus</i> sp.	-	-	-	B
<i>Cyclotella</i> sp.	X	-	-	C
<i>Cyclotella ocellata</i> Grunow	-	-	-	A
<i>Cyclotella meneghiniana</i> Kutzing	-	C	X	X
<i>Cyclotella striata</i> (Kutzing) Grunow	-	-	-	A
<i>Cymbella</i> sp.	-	-	-	X
<i>Cymbella ventricosa</i> Agardh	-	-	X	X
<i>Epithemia argus</i> (Ehrenberg) Kutzing	-	B	X	-
<i>Enantia praecipua</i> Ehrenberg	-	Y	-	-

	W	S	S	F
<i>Frigitularia</i> sp.	-	X	-	-
<i>Frigitularia bipinnatifida</i> Desmazieres	-	-	X	X
<i>Frigitularia angustifolia</i> Skovtsov	-	-	-	X
<i>Frigitularia scutellariaefolia</i> (L.) Link.	-	-	-	X
<i>Frigitulariopsis cylindrica</i> (Rumov.) Helmeke et Krieger	-	X	X	-
<i>Gymnatophora marina</i> (Lynhbye) Kutzing	-	-	-	X
<i>Gyrogonia lufitiana</i> (Lynhberg) Clive	-	X	X	X
<i>Licorhizum</i> sp.	-	X	-	-
<i>Littorophora parvula</i> (Lynhbye) Agardh	X	-	-	-
<i>Melostira granulata</i> (Lynhberg) Hall	-	-	-	-
<i>Melostira granulata angustifolia</i> Muller	-	-	-	-
<i>Nuphula</i> sp.	-	-	-	X
<i>Nuphula corollae</i> Leunkeles Hustedt	-	-	-	X
<i>Nuphula arctica</i> Hustedt	-	X	X	X
<i>Nuphula atomaria</i> (Kutzing) Grunow	-	X	X	-
<i>Nuphula lewinii</i> W. Smith	-	-	X	-
<i>Nuphula terebinthina</i> Brethaus	-	-	-	X
<i>Nuphula corymbosa</i> Grunow	-	-	X	-
<i>Nuphula lamellosa</i> var. <i>f. f.</i> (Kutzing) Clive	-	-	X	-
<i>Nuphula maculata</i> (Bailey) Clive	X	-	-	X
<i>Nuphula arctica</i> Grunow	-	-	-	X
<i>Nuphula subulmaria</i> Grunow	X	-	-	X

Table 1. (continued)

	W	S	S	F		W	S	S	F
<i>Nitzschia</i> sp.	-	X	X	-	<i>Euglena fluvi</i> (Klebs) Lemmermann	-	-	-	X
<i>Nitzschia amphibia</i> Cronan	-	X	X	-	<i>Euglena mutabilis</i> var. <i>mutabilis</i> Goldies	-	-	X	-
<i>Nitzschia clausii</i> Hantzsch	X	C	X	X	<i>Euglena procliva</i> Dangard	-	-	X	X
<i>Nitzschia closterium</i> (Ehrenberg) W. Smith	X	X	X	B	<i>Euglena puerili</i> Campbell	-	-	-	C
<i>Nitzschia communis</i> var. <i>hyalina</i> Lund	-	-	C	X	<i>Eutrypa laquei</i> Steyer	-	-	-	-
<i>Nitzschia longissima</i> (Ehrbisson) Ralfs	-	-	X	X	<i>Eutrypa viridis</i> Percy	X	-	-	-
<i>Nitzschia parvula</i> (Gmelin) Grun	-	-	X	X	<i>Phaeus</i> sp. #1	-	-	-	C
<i>Nitzschia proxima</i> Husted	-	-	-	X	<i>Phaeus</i> sp. #2	X	-	-	-
<i>Nitzschia sigmoides</i> Husted	-	-	-	X	<i>Phaeus curvicauda</i> Swirensko	-	-	-	X
<i>Nitzschia vermicularis</i> (Kutzing) Hantzsch	C	X	X	X	<i>Phaeus lemmermanni</i> (Swirensko) Skvortzow	-	-	X	-
					<i>Phaeus longicauda</i> (Ehrenberg) Badarín	-	-	C	X
<i>Pinnularia</i> sp.	-	-	X	X	<i>Traehelomonas</i> sp.	-	-	X	X
<i>Pinnularia major</i> (Kutzing) Rabenhorst	-	-	-	X	<i>Traehelomonas acanthostoma</i> (Stokes) Deflandre	-	-	-	X
<i>Pinnularia rotangulata</i> (Gregory) Cleve	-	-	-	X	<i>Traehelomonas oharkouensis</i> Swirensko	-	-	-	X
<i>Platygramma staurorhynchum</i> (Gregory) Heiberg	-	-	-	X	<i>Traehelomonas hapida</i> (Perty) Stein	X	C	B	X
<i>Rhabdonema minutum</i> Kutzing	-	-	C	B	<i>Traehelomonas hapida</i> var. <i>punctata</i> Lemmermann	-	-	-	X
<i>Stauroneis clovea</i> var. <i>hyalina</i> Peragallo	-	B	X	-	<i>Traehelomonas volucria</i> var. <i>punctata</i> Playfair	-	-	C	-
<i>Stauroneis fastuosa</i> Ehrenberg	X	-	-	-					
<i>Stauroneis striatula</i> Turpin	B	X	C	X	Cyanophyceae				
<i>Tropidoneis lapidoptera</i> (Gregory) Cleve	B	-	X	X	<i>Agmenellum quadriplicatum</i> (Meneghini) Brebisson	-	-	-	X
Unknown Centrales species	-	-	A	-	<i>Anabaena</i> sp.	-	-	-	X
Chlorophyceae					<i>Anagatis aeruginosa</i> Drouot et Bailly	-	-	-	X
<i>Ankistrodesmus falcatus</i> (Corda) Ralfs	-	-	-	X	<i>Anagatis elvridata</i> (Kutzing) Drouot et Bailly	C	X	-	X
<i>Ankistrodesmus falcatus</i> var. <i>acicularis</i> (A. Braun) G. S. West	-	-	-	X	<i>Anagatis marina</i> (Hansgirg) Drouot et Bailly	C	-	-	X
<i>Chlamydomonas</i> sp.	-	X	X	X	<i>Anagatis montana minor</i> (Willie) Drouot et Bailly	-	-	-	X
<i>Chlorella</i> sp.	-	X	X	-	<i>Anagatis thermalis</i> (Meneghini) Drouot et Bailly	-	-	-	X
<i>Chlorella ellipsoidea</i> Cerneck	-	-	X	C	<i>Calothrix parietalis</i> Thuret	-	-	-	X
<i>Chlorella vulgaris</i> Beijerinck	X	-	X	-	<i>Gomphosphaeria apocina</i> Kutzing	-	-	-	X
<i>Kriohierella lunaris</i> (Kirchner) Nobius	-	B	C	-	<i>Johannesbaptista pellucida</i> (Dickie) Taylor et Drouot	X	X	X	X
<i>Nannochloris atomus</i> Butcher	B	A	A	B	<i>Maroccoleus lyngbyaceus</i> (Kutzing) Crouan	-	-	-	X
<i>Oedogonium</i> sp. #1	-	-	-	X	<i>Nostoc commune</i> Vaucher	-	-	C	X
<i>Oedogonium</i> sp. #2	-	-	X	C	<i>Oscillatoria</i> sp.	-	X	-	-
<i>Oedogonium</i> sp. #3	-	X	X	-	<i>Oscillatoria lutea</i> Agardh	-	-	X	-
<i>Oedogonium pungenis</i> Hirn	-	-	X	-	<i>Oscillatoria submicrococcoides</i> Ardissonne et Strafforella	C	X	C	X
<i>Oocystis</i> sp.	-	X	X	X	<i>Schizothrix arenaria</i> (Berkeley) Gomont	-	-	-	X
<i>Scenedesmus</i> sp. #1	-	-	-	X	<i>Schizothrix calicicola</i> (Agardh) Gomont	-	-	-	X
<i>Scenedesmus</i> sp. #2	-	-	-	B	<i>Spirulina subulacea</i> Gersted	-	-	X	X
<i>Scenedesmus brygia</i> (Turpin) Lagerheim	-	-	-	X					
<i>Scenedesmus quadricauda</i> (Turpin) Brebisson	-	-	-	X	Dinophyceae				
<i>Staurastrum</i> sp.	-	-	-	X	<i>Goniolax diatomis</i> (Heunier) Schiller	-	-	-	X
<i>Tetradonion</i> sp.	-	-	-	X	<i>Gymnodinium</i> sp. #1	-	-	-	X
<i>Tetradonion medium</i> (A. Braun) Hansgirg	-	-	-	C	<i>Gymnodinium</i> sp. #2	X	X	X	X
Unidentified Oocystacean	C	-	-	-	<i>Gymnodinium danicoma</i> Campbell	-	-	C	X
					<i>Gymnodinium estuariae</i> Hulbert	-	-	X	-
Prasinophyceae					<i>Protoperidinium</i> sp.	-	-	-	X
<i>Pyramimonas micron</i> Conrad and Kufferath	-	-	-	X	<i>Protoperidinium asporum</i> (Levander) Balech	-	-	X	X
<i>Tetraselmis maculata</i> Butcher	-	-	-	X	<i>Protoperidinium pentagonum</i> (Cran) Balech	-	-	X	X
Cryptophyceae					Others				
<i>Chroomonas amphioxeia</i> (Conrad) Butcher	-	X	X	-	<i>Campylopus oerules</i> Balbis	-	-	-	X
<i>Chroomonas salina</i> (Wislouch) Butcher	-	-	-	X	<i>Leish minor</i> L.	-	-	-	X
<i>Cryptomonas</i> sp.	-	-	-	X	Unidentified ultraplankton	X	B	B	X
<i>Cryptomonas irregularis</i> Butcher	-	-	-	X					
<i>Cryptomonas rostrata</i> Lucas	-	-	-	C					
<i>Plagiocelmis</i> sp.	-	-	-	X					
Chrysophyceae									
<i>Chryomonas ovalis</i> Walff	-	-	-	X					
<i>Chryomonas uulfi</i> Conrad and Kuff.	X	-	-	-					
<i>Chromulina parvula</i> Conrad	-	-	-	X					
<i>Chrysococconeus minutus</i> (Fritsch) Nygaard	-	-	-	B					
<i>Hallomonas</i> sp.	-	-	-	X					
<i>Ochromonas minuta</i> H. Neyer	-	-	-	X					
<i>Ochromonas variabilis</i> H. Neyer	-	-	-	B					
Xanthophyceae									
<i>Monodus guttula</i> Pascher	X	-	-	X					
<i>Nephrochloris salina</i> Pascher	-	-	-	X					
<i>Trilonema affine</i> G. S. West	-	X	X	X					
<i>Trilonema minus</i> (Willie) Hazen	-	-	-	X					
<i>Trilonema monochloron</i> Pascher et Geitler	-	X	X	-					
Haptophyceae									
<i>Chrysochromulina minor</i> Parke et Manton	-	-	-	X					
<i>Valoniella salina</i> (Carter) Green	-	-	-	X					
Euglenophyceae									
<i>Euglena</i> sp.	-	-	-	X					
<i>Euglena acus</i> Ehrenberg	-	-	-	X					
<i>Euglena agilis</i> Carter	-	-	-	X					
<i>Euglena densa</i> Ehrenberg	-	-	-	X					
<i>Euglena ehrenbergii</i> Klebs	-	-	-	C					

Literature Cited

- Bourrelly, P. 1966. Les Algues d'eau douce. Tome 1: Les Algues Vertes. N. Boubee & Cie, Paris, pp. 159-188.
- Hendey, N. I. 1974. A revised check-list of British marine diatoms. J. Mar. Biol. Ass. U.K., 54: 277-300.
- Marshall, H. G. and D. E. Bowker. 1976. The use of Skylab in the study of productivity along the eastern shelf waters of the United States. NASA Tech. Rep. NAS1-11707, 1-26.
- Marshall, H. G. and K. K. Nesius, and S. J. Cibik. 1980. Phytoplankton studies within the Virginia Barrier Islands. II. Seasonal study of phytoplankton within the Barrier Island complex. Castanea. In Press.
- Nemeth, J. C. 1969. The summer Chlorophyceae and Cyanophyceae of the Delmarva Peninsula, Virginia. Castanea, 34:81-86.
- Parke, M. and P. S. Dixon. 1976. Checklist of British marine algae. Third Revision. J. Mar. Biol. Ass. U.K., 56:527-594.
- Simpson, P. and S. VanValkenburg. 1978. The ultrastructure of *Mychonastes ruminatus* Gen. et sp. Nov., A new member of the chlorophyceae isolated from brackish water. Br. Phycol. J., 13:117-130.
- Strickland, J. D. H. 1960. Measuring the production of marine phytoplankton. Bull. Fish. Res. Bd. Canada. No. 122: 178 p.

Analysis of Site Specificity for Protein Hydrolysis by the Alkaline Protease of *Neurospora crassa*

Lloyd Wolfinbarger, Jr.

Department of Biological Sciences
Old Dominion University
Norfolk, Virginia 23508

Abstract—The specificity of the extracellularly derived alkaline protease from *Neurospora crassa* was determined by hydrolysis of the oxidized B-chain of insulin. The DNP-derivatives and hydrazinolysis products suggest that this serine protease preferentially hydrolyzes peptide bonds on the carboxyl group side of neutral and aromatic amino acids.

Introduction

The ascomycete fungus *Neurospora crassa* is capable of growing on proteins as a sole source of carbon, nitrogen, or sulfur. Under such growth limiting conditions a total of three extracellular proteolytic species are synthesized and secreted into the media. The three proteolytic species have been identified as an acid protease (optimal activity at pH 5-6), a neutral protease (optimal activity at pH 7.0) and an alkaline protease (optimal activity at pH 8-9) (Heininger and Matile 1974, Drucker 1975, and Hanson and Marzluf 1975). The neutral protease is extremely unstable and is quickly inactivated by most purification schemes. The acid protease has not been extensively purified and thus its site specificity for protein hydrolysis has not been determined. The alkaline protease is a serine-protease and has recently been isolated to homogeneity (Price, Wolfinbarger, Drucker, and Marzluf, submitted for publication). We report here that this protease is similar to chymotrypsin in that it preferentially hydrolyzes peptide bonds on the carboxyl-group side of neutral and aromatic amino acids.

Materials and Methods

Enzymatic digestion of oxidized B-chain of Insulin

Determination of the sites of hydrolysis by the alkaline protease was accomplished by combining 5.0 mg of the B-chain of insulin with 0.1 mg purified *N. crassa* alkaline protease and incubating for 30 minutes, at 37°C, in 1 ml of 1% triethylamine buffer (pH 9.0) (Nakanishi and Yamamoto 1975). The reaction was terminated by freezing.

Determination of amino-terminal residues

The amino-terminal residue-amino acids of the peptides liberated by the above enzymatic digestion were analyzed by making fluorodinitrobenzene (FDNB) derivatives of the peptides, acid hydrolyzing them, and subjecting the products to thin layer chromatographic determination. As a control, insulin plus protease (which were not allowed to react) were also derivatized with FDNB.

Specifically, 1 mg of FDNB, in 1 ml of 95% ethanol, was added to the thawed enzymatic digest and shaken at room temperature for 3 hours. The pH was maintained by addition of 1% triethylamine (pH 9.0). At the end of 3 hours the reaction mixture was repeatedly extracted with diethyl ether until the ether extract was clear. The aqueous phase was then acidified with HCl (pH < 2.0) and the resulting precipitate and aqueous phase were then extracted into diethyl ether, taken to dryness over Drierite and KOH, and labeled extracts 2 and 3 respectively.

Extracts 2 and 3 were then acid hydrolyzed in 6 N HCl, at 100°C for 6 hours, in tubes flushed with dry nitrogen prior to sealing. The hydrolysis products were dried in a vacuum over KOH, redissolved in ether, spotted onto cellulose thin layer chromatographic plates (Eastman) and chromatographed in two dimensions using ammonia saturated 1-butanol and phosphate buffer (1.0 M KH_2PO_4 plus 0.5 M K_2HPO_4), first and second dimensions respectively. Identities of the FDNB derivatives were confirmed using known FDNB derivatized DNP-amino acids (Sigma Chem. Co.).

Determination of carboxyl-terminal residues

The carboxyl-terminal amino acid residues of the peptides liberated by the proteolytic digestion of insulin were determined by hydrazinolysis of the peptide fragments. Again a control of nonreacted insulin plus protease was treated in a manner identical to the experimental sample.

In this instance the enzymatic digestion products were lyophilized prior to the addition of 25 mg of hydrazine sulfate. The digestion products, dissolved in hydrazine sulfate, were frozen to -40°C, vacuum sealed in a hydrolysis tube, and heated at 60°C for 16 hours to derivatize the peptides.

At the end of this time the seal was broken and the tubes freed of hydrazine by holding under vacuum over concentrated H_2SO_4 and P_2O_5 for 4 hours followed by high-vacuum drying overnight. The residue in each tube was then dissolved in a minimal volume of distilled water and passed over a column of IRC-50 (H^+ -form). Neutral amino acids were eluted with approximately 15 mls distilled water and the basic amino acids were eluted with 15 ml of 0.1 M ammonium acetate (pH 7.0). Both eluents of each sample were lyophilized and redissolved in Beckman amino acid analyzer buffer. These solutions were then subjected to analysis using a Beckman amino acid analyzer.

Results and Discussion

The DNP-amino acid derivatives obtained were DNP-phenylalanine DNP-proline, DNP-valine, DNP-glycine, and DNP-glutamic acid (Figure 1). The derivatized amino acids found in the extracts 1 (soluble) and 2 (precipitable material) differed only in a quantitative manner except for a small, barely detectable, quantity of DNP-serine found in extract 2—the acid precipitable material. Because of the difficulty in correctly indentifying individual DNP-amino acid derivatives by their respective R_f values we resorted to co-chromatography of experimental samples with known DNP-amino acid derivatives. If we were not correct in identification of a particular DNP-derivative we would obtain additional yellow spots on our TLC sheets. Using this modified procedure we were able to ascertain that the DNP-valine reported here was not DNP-leucine as we had originally thought. (DNP-leucine and DNP-valine migrate close together on the TLC sheet using the solvent systems described in this study.)

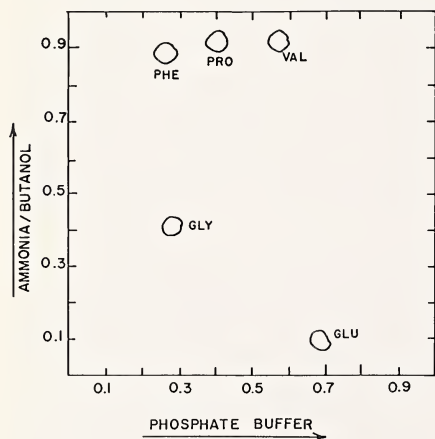


FIG. 1—Thin layer chromatograph of DNP-derivatives obtained from peptide fragments liberated by alkaline protease digestion. In order to normalize each chromatographic analysis the R_f values for each spot were calculated for each solvent system and plotted.

The free amino acid residues remaining after hydrolysis of the peptide fragments were determined by use of a Beckman amino acid analyzer (Figure 2). Identities of the eluting ninhydrin positive materials are determined by comparing elution times with the corresponding elution times of amino acid standards. Norleucine is included in the sample application buffer to act as an internal standard for each analysis.

In order to get the DNP-amino acid derivatives indicated in figure 1 the alkaline protease would have

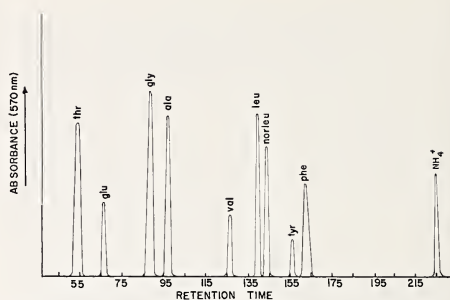


FIG. 2—Amino acid analysis of free amino acids liberated by hydrolysis of peptide fragments liberated by alkaline protease digestion. Absorbance is monitored as ninhydrin positive material eluting from the column resin and is presented here without absolute values. The retention time represents the time, in minutes, that each compound remains bound to the column resin. In order to be identified as a specific amino acid its elution time had to fall within one minute of an amino acid standard.

had to cleave peptide bonds on the carboxyl side of residues 1, 3 (minor), 7, 11, 12 (minor), 17, 19, 20 (minor), 22, 23, 24, and 27. The hydrolysis products suggest an enzymatic cleavage on the carboxyl side of residues 1, 2 (minor), 6, 8, 11, 12 (minor), 14, 15, 16 (minor), 17, 18 (minor), 20, 21 (minor), 23, 24, 25, 26 (minor), and 27. Evaluation of presumptive cleavage sites common to both the DNP-derivatives and hydrazide-derivatives suggested the following sites of enzymatic hydrolysis: between residues 1 and 2, 11 and 12, 12 and 13 (minor), 17 and 18, 20 and 21, 23 and 24, 24 and 25, and 27 and 28 (Figure 3).

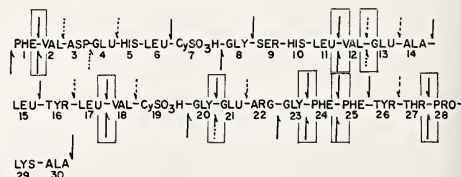


FIG. 3—Cleavage points of oxidized B-chain of insulin by the *Neurospora* alkaline protease. The arrows along the top of the protein fragment reveal presumptive hydrolysis sites as indicated by the hydrolysis products. The arrows along the bottom of the protein reveal hydrolysis sites as indicated by the DNP-derivatives obtained. Sites common to both are "boxed-in". Solid arrows represent major and dashed arrows indicate minor sites of hydrolysis.

Obviously longer or shorter incubation times would yield different peptide fragments and hence indicate different sites for hydrolysis. However, the data does suggest that the *Neurospora crassa* alkaline protease preferentially hydrolyzes peptide bonds on the carboxyl group side of neutral and aromatic amino acids.

In addition, the peptides liberated from the oxidized B-chain of insulin, and presumably from other protein substrates, would be small enough to be transported by the oligopeptide transport system reportedly (Wolfenbarger and Marzluf 1975) present in *Neurospora crassa*. Such transport would be necessary before *Neurospora* could utilize the amino acid residues present in a protein as a source of some required nutrient (Wolfenbarger and Marzluf 1974).

Literature Cited

- Drucker, H. (1975) Regulation of Exocellular Proteases in *Neurospora crassa*: Metabolic Requirements of the Process. *J. Bacteriol.* 122:1117-1125.
- Hanson, M. A. and Marzluf, G. A. (1975) Control of the Synthesis of a Single Enzyme by Multiple Regulatory Circuits in *Neurospora crassa*. *Proc. Nat. Acad. Sci. USA* 72:1240-1244.
- Heininger, U. and Matile, Ph. (1974) Protease Secretion in *Neurospora crassa*. *Biochim. Biophys. Res. Comm.* 60:1425-1432.
- Nakanishi, T. and Yamamoto, T. (1975) The Initial Attack Sites of a *Streptomyces* Alkaline Proteinase on Oxidized Insulin B-chain. *Agr. Biol. Chem.* 39:1797-1802.
- Wolfenbarger, Jr., L. and Marzluf, G. A. (1974) Peptide Utilization by Amino Acid Auxotrophs of *Neurospora crassa*. *J. Bacteriol.* 119:371.
- Wolfenbarger, Jr., L. and Marzluf, G. A. (1975) Size Restriction on Peptide Utilization by Amino Acid Auxotrophs of *Neurospora crassa*. *J. Bacteriol.* 122:949.

OBITUARY

John C. Strickland

Dr. John C. Strickland, 65, a specialist in blue-green algae and former chairman of the University of Richmond biology department, died February 23, 1980 in Richmond.

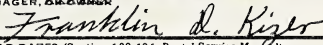
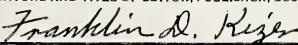
A native of Petersburg, Dr. Strickland was awarded a bachelor's degree from the University of Richmond and earned a master of arts degree and a Ph.D. at the University of Virginia.

He taught biology at the College of William and Mary for three years and then joined the University of Richmond faculty in 1946 as an assistant professor. He was promoted to full professor in 1958 and served as chairman of the department from 1957 until 1965. He remained a professor of biology at UR until his retirement last year.

Dr. Strickland published a number of papers on the classification and culture of various strains of blue-green algae. He was a member of the Virginia Academy of Science, of Sigma Xi, the Botanical Society of America, of the American Society of Plant Taxonomists and of the Society for Economic Botany. He also belonged to the North Carolina and California Academies of Science.

He was a fellow of the American Association for the Advancement of Science and a member of the Phycological societies of America and Britain, the International Phycological Society and the International Association for Plant Taxonomy.

The family suggests that memorial gifts be made to the University of Richmond's Science Library.

U.S. POSTAL SERVICE			
STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION			
(Required by 39 U.S.C. 3685)			
1. TITLE OF PUBLICATION Virginia Journal of Science		A. PUBLICATION NO. 6 6 0 5 8 0	
3. FREQUENCY OF ISSUE quarterly - Spring, Summer, Winter, Fall		2. DATE OF FILING Sept. 1, 1980	
4. LOCATION OF KNOWN OFFICE OF PUBLICATION (Street, City, County, State and ZIP Code) (Not printers) P.O. Box 8454, Richmond, Virginia 23226		B. ANNUAL SUBSCRIPTION PRICE \$15.00	
5. LOCATION OF THE HEADQUARTERS OR GENERAL BUSINESS OFFICES OF THE PUBLISHERS (Not printers) P.O. Box 8454, Richmond, Virginia 23226			
6. NAMES AND COMPLETE ADDRESSES OF PUBLISHER, EDITOR, AND MANAGING EDITOR			
PUBLISHER (Name and Address) Virginia Academy of Science P.O. Box 8454, Richmond, Va., 23226			
EDITOR (Name and Address) College of William and Mary Dr. Stewart A. Ware, Dept. of Biology, Williamsburg, Virginia 23185			
MANAGING EDITOR (Name and Address) Franklin D. Kizer, Business Manager, Rt. 2, Box 637, Lancaster, Va. 22503			
7. OWNER (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual must be giving. If the publication is published by a nonprofit organization, its name and address must be stated.)			
NAME		ADDRESS	
Virginia Academy of Science		P.O. Box 8454, Richmond, Va. 23226	
8. KNOWN BONDHOLDERS, MORTGAGEES, AND OTHER SECURITY HOLDERS OWNING OR HOLDING 1 PERCENT OR MORE OF TOTAL AMOUNT OF BONDS, MORTGAGES OR OTHER SECURITIES (If there are none, so state)			
NAME		ADDRESS	
NONE			
9. FOR COMPLETION BY NONPROFIT ORGANIZATIONS AUTHORIZED TO MAIL AT SPECIAL RATES (Section 132.122, PSN) The purpose, function, and nonprofit status of this organization and the exempt status for Federal income tax purposes (Check one)			
<input checked="" type="checkbox"/> HAVE NOT CHANGED DURING PRECEDING 12 MONTHS <input type="checkbox"/> HAVE CHANGED DURING PRECEDING 12 MONTHS (If changed, publisher must submit explanation of change with this statement.)			
10. EXTENT AND NATURE OF CIRCULATION		AVERAGE NO. COPIES EACH ISSUE DURING PRECEDING 12 MONTHS	
A. TOTAL NO. COPIES PRINTED (Net Press Run)		2 000	
B. PAID CIRCULATION		2 000	
1. SALES THROUGH DEALERS AND CARRIERS, STREET VENDORS AND COUNTER SALES		0	
2. MAIL SUBSCRIPTIONS		1 659	
C. TOTAL PAID CIRCULATION (Sum of 10B1 and 10B2)		1 700	
D. FREE DISTRIBUTION BY MAIL, CARRIER OR OTHER MEANS SAMPLES, COMPLIMENTARY, AND OTHER FREE COPIES		0	
E. TOTAL DISTRIBUTION (Sum of C and D)		1 659	
F. COPIES NOT DISTRIBUTED		1 700	
1. OFFICE USE, LEFT OVER, UNACCOUNTED, SPOILED AFTER PRINTING		341	
2. RETURNS FROM NEWS AGENTS		0	
G. TOTAL (Sum of E, F1 and 2—should equal net press run shown in A)		2 000	
11. I certify that the statements made by me above are correct and complete.		SIGNATURE AND TITLE OF PUBLISHER, BUSINESS MANAGER, OR OWNER  Franklin D. Kizer	
12. FOR COMPLETION BY PUBLISHERS MAILING AT THE REGULAR RATES (Section 132.121, Postal Service Manual)			
39 U.S.C. 3626 provides in pertinent part: "No person who would have been entitled to mail matter under former section 4359 of this title shall mail such matter at the rates provided under this subsection unless he files annually with the Postal Service a written request for permission to mail matter at such rates."			
In accordance with the provisions of this statute, I hereby request permission to mail the publication named in Item 1 at the phased postage rates presently authorized by 39 U.S.C. 3626.			
SIGNATURE AND TITLE OF EDITOR, PUBLISHER, BUSINESS MANAGER, OR OWNER  Business Manager			



VIRGINIA JOURNAL OF SCIENCE

VOL. 31, NO. 4
WINTER 1980

505, 73
V81

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware

Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer

Box 637
Lancaster, Va. 22503

SECTION EDITORS

Agricultural Sciences

R. J. Stipes
417A Price Hall
VPI & SU
Blacksburg, Va. 24061

Physics

Dr. W. Peter Trower
Dept. of Physics
VPI & SU
Blacksburg, Va. 24061

Biology

Patrick F. Scanlon
Dept. of Fisheries & Wildlife
VPI & SU
Blacksburg, Va. 24061

Botany

David A. Breil
Dept. of Natural Sciences
Longwood College
Farmville, Va. 23901

Chemistry

Robert G. Bass
Dept. of Chemistry
Va. Commonwealth Univ.
Richmond, Va. 23284

Education

C. Dillard Haley
Dept. of Education
900 Fairfax St.
Radford, Va. 24141

Engineering

Walter R. Hibbard
301 Holden Hall
VPI & SU
Blacksburg, Va. 24061

Environmental Sciences

Michael Garstang
Dept. of Env. Science
Univ. of Virginia
Charlottesville, Va. 22904

Geology

Roddy V. Amenta
Dept. of Geology
James Madison Univ.
Harrisonburg, Va. 22801

Materials Science

John C. Duke, Jr.
Dept. of Eng. Sci. & Mechanics
VPI & SU
Blacksburg, Va. 24061

Medical Sciences

Charles O'Neill
Dept. of Biophysics
MCV
Richmond, Va. 23298

Microbiology

Paul V. Phibbs, Jr.
Dept. of Microbiology
MCV-VCU
Richmond, Va. 23298

Psychology

Frank S. Murray
Psychology Dept.
Randolph-Macon Women's
College
Lynchburg, Va. 24503

Space Science & Technology

Sam S. Fisher
Dept. of Mechanical and
Aero-Space Engineering
Thorton Hall, Univ. of Va.
Charlottesville, Va. 22901

Statistics

J. Van Bowen, Jr.
Dept. of Mathematics
Univ. of Richmond
Richmond, Va. 23172

©Copyright, 1980 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P.O. 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia and additional entry at Harrisonburg, Virginia 22801. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1980: \$15.00 per year, U.S.A.; \$20.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$4.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send address changes to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper (8½ × 11 inches). Margins should be not less than 1¼ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and affiliation, and proposed running title, all appear-

ing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first and last page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. *Metamorphic Textures*. Pergamon Press, New York. 350 pp.

Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians, Part III. Vertebrates* (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 31

No. 4

Winter 1980

TABLE OF CONTENTS

COMMITTEE REPORTS

Archives	70
Awards	70
Constitution & Bylaws	70
Finance and Endowment	71
Flora	73
Membership	73
Publications	73
Research	74
Science Advisory Plan	74
Science Education	74
Visiting Scientists Program	74

ABSTRACTS OF PAPERS, *Fifty-Eighth Annual Meeting of the Virginia Academy of Science, May 13-16, 1980, University of Virginia, Charlottesville.*

Agricultural Sciences	76
Astronomy, Mathematics, and Physics	90
Biology	96
Botany	104
Chemistry	109
Education	118
Engineering	120
Environmental Science	124
Geology	126
Materials Science	128
Medical Sciences	132
Microbiology	139
Space Science and Technology	141
Statistics	143

Virginia Academy of Science

Fifty-Eighth Annual Meeting, University of Virginia

May 13-16, 1980

Archives Committee

With regard to the prospect of naming the Virginia Tech Library as the permanent repository for the Archives, the Committee has this recommendation:

1. The Academy should retain ownership of all documents now in its possession, or later directed to the Archives.
2. Records, documents, or other material to be added to the Archives Collection should be channeled through the Committee, rather than directly to the Virginia Tech Library. This will permit the Academy to retain control of the program.
3. The present collection and any later additions should be transferred to the Virginia Tech Library for permanent storage with this understanding:
 - a. The Virginia Tech Library is to serve as the "custodian" of the collection until further notice.
 - b. At such time as the Academy may choose to relocate its repository for the Archives, the Academy will provide copies of any unpublished material catalogued by the Virginia Tech Library.
4. The Ad Hoc Committee on Archives, in conjunction with administrators at the Virginia Tech Library, will endeavor to jointly develop procedures for use of the Archival material.

Be it further understood that VPI & SU Library will provide a designated area for the housing of VAS documents.

Be it resolved that the aforementioned be referred to the Executive Committee for formal agreement and implementation.

This resolution was passed by Council and referred to the Executive Committee for implementation, with the understanding that the VPI Librarian would also agree to the procedures.

Boyd Harshbarger, Chairman

Awards Committee

The Committee reviewed nominations and recommended to Council election as Fellows of the Virginia Academy of Science: Dorothy Crandall Bliss, Professor of Biology, Randolph-Macon Woman's College; Elizabeth Burger Jackson, Professor Emerita of Natural Sciences, Longwood College; Ralph Addison Lowry, John Lloyd Newcomb Professor of Engineering and Applied Science, University of Virginia and President of the Academy, 1977-1978; James W. Midyette, Jr., Director of Administration, Depart-

ment of Agriculture and Commerce, Commonwealth of Virginia; Helmut R. R. Wakeham, Vice President, Philip Morris Inc., and Vice President, Science and Technology, Philip Morris USA, Richmond, Virginia.

The Committee proposed and recommended to Council, election as Honorary Life Members in the Virginia Academy of Science, Dr. Mary E. Kapp, Professor Emerita of Chemistry, Virginia Commonwealth University and Dr. Robert F. Smart, Professor Emeritus of Biology, University of Richmond and President of the Academy, 1944-1945, in recognition of their long service and devotion to the Academy.

The Committee proposed and recommended to Council that a special award be presented at the May 1980 meeting to charter member Dr. Leonidas Rosser Littleton, Chemistry Professor Emeritus of Emory and Henry College honoring him in recognition of his 57 years as an active and charter member.

Professor Ruskin S. Freer, Professor Emeritus of Biology, Lynchburg College and President of the Academy 1939-1940, one of the Academy's oldest but still active scientists, was selected as recipient of the Ivey F. Lewis Distinguished Service Award for 1980. His contributions to the Virginia Academy of Science and to science in the Commonwealth of Virginia and beyond are eminently outstanding.

Lynn D. Abbot, Jr., Chairman

Constitution and Bylaws Committee

I. *Constitutional Amendments.* The following were adopted at the 1980 Academy Conference.

Change - 1. ARTICLE III, Section 6. Standing Committees, as follows; Change the words "*Nominating Committee*" to read "*Nominations and Elections Committee*" further, following "*the Constitution and Bylaws Committee*," insert "*Science Advisory Committee*."

Change - 2. ARTICLE X: ELECTION OF ACADEMY AND SECTION OFFICERS amend to read; Section 1. A "Nominations and Elections Committee," consisting of three recent Past Presidents, appointed by the President shall establish a slate of nominations for the positions of President-elect, Secretary and Treasurer and conduct an election for same in accordance with procedures specified by Academy Bylaws. (See proposed Bylaws)

Section 2. Upon election, such officers shall serve one-year terms commencing at the annual meeting at which their election is announced and continuing until the next annual meeting; pro-

vided, however, the President-elect shall automatically ascend to the position of President at the end of his scheduled term of office or at any prior time that the office of President may be vacated; however, such person shall not serve as President beyond the term that such person was originally scheduled to serve.

Section 3. All interim vacancies in Academy offices, other than President, shall be filled by Council from names of members nominated by the Executive Committee. Officers so selected shall serve through the next subsequent annual meeting.

II. Amendments to Bylaws. These amendments to the Bylaws were adopted at the 1980 Academy Conference.

Change - 1. ARTICLE I: TYPES OF MEMBERSHIP AND DUES

Section 2. Amend paragraph (5) to read; To be in good standing the foregoing types of members must pay the specified dues by July 1.

Change - 2. ARTICLE III: DUTIES OF STANDING COMMITTEES

Section 4. Membership Committee shall:

(3) Amend to read; Sponsor a Business Advisory committee for the purpose of creating understanding between science and business, and to solicit business memberships and contributions to the Academy. *Any business which contributes \$500 or more annually shall be designated as a "Sponsoring Organization" and appropriately recognized as such.*

Change - 3. Strike present Section 10 and add following: Section 10. Nominations and Elections Committee shall:

- (1) Mail to the membership prior to January 1 each year a request for nominations of persons to fill the offices of President-elect, Secretary and Treasurer.
- (2) Nominate a slate of two persons for each of the aforementioned offices and present to March Council Meeting for approval.
- (3) Mail slate of nominees to members advising that names may be added to the slate by 25 members petitioning the committee on behalf of each name to be added.
- (4) Prepare ballots with or without additional nominees as the case may be and mail to membership with registration and other information relative to annual meeting indicating deadline and address for return to committee.
- (5) Count ballots and announce results at the Academy Conference. Should a tie vote result for any office, the Academy Conference shall vote on the nominees. In all cases, the nominee receiving the largest number of favorable votes shall be elected; provided, however, that only members in good standing may cast ballots.

Change - 4. Add new Section as follows:

Section 13. The Science Advisory Committee shall:

- (1) Provide scientific and technical information and advice requested by the Executive, Legislative, and other governmental bodies and agencies of the Commonwealth of Virginia.
- (2) Serve as liaison for the collection and transfer of scientific information and/or advice solicited in (1).
- (3) Collect and evaluate suggestions and opinions regarding topics of general public interest wherein science and technology may provide assistance, but where such assistance has not been requested. The Science Advisory Committee will make recommendations to the Academy, to the Executive Committee, and/or the Council of the Academy for review and approval. The Science Advisory Committee, upon direction of Council or Executive Committee, shall serve as a conduit for placement of such information before the appropriate Executive, Legislative, or other governmental body or agency.
- (4) Maintain an inventory of scientific interests and expertise of individuals within the Academy who are willing to serve in an advisory and/or consultant capacity to state government.
- (5) At no time operate beyond constraints considered as proper conduct for a non-profit organization.
- (6) Append all reports and recommendations with a statement as follows: "The Virginia Academy of Science assumes no legal or financial responsibility for the utilization or dispersal of scientific and technical data or advice provided by the Science Advisory Committee, further, the Academy assumes no responsibility, financial or otherwise, to governmental agents or agencies, institutions, individuals or committee members pursuant to the conduct and activities of this committee.

Change - 5. ARTICLE VI: THE DULY ORGANIZED SCIENTIFIC SECTIONS OF THE ACADEMY ARE:

Stirke; (13) Space Science

Add; (13) Aeronautical and Aerospace Sciences
J. W. Midyette, Jr., Chairman

Finance and Endowment Committee

From the Summary of Receipts and Disbursements for 1973-79 (Table I), the following highlights may be noted regarding our most recent fiscal year ended 31 December:

1. Gift income for the second consecutive year is about double the average of the last decade and promises to be even higher in 1980-81. Exceptional credit is due the VJAS Committee which is

SUMMARY OF RECEIPTS AND DISBURSEMENTS - 1973-1979

	1973	1974	1975	1976	1977	1978	1979	Budget 1980
RECEIPTS								
Dues	\$16,913	\$19,631	\$18,721	\$18,290	\$16,352	\$16,950	\$18,200	\$18,100
Gifts	2,276	2,120	2,505	2,130	2,977	5,417	5,327	7,200
Annual Meeting	5,497	4,040	5,323	5,794	5,278	9,164	6,666	6,900
Virginia Journal	4,312	5,168	2,013	1,966	2,568	4,014	2,855	1,650
Interest	1,425	1,618	1,780	2,130	2,223	1,802	2,676	1,800
Inc. from Trust Fund	--	2,039	2,000	2,000	3,000	2,200	2,200	3,300
Other	635	500	676	606	455	674	417	--
From Savings & Others	--	--	--	--	--	1,693	8,398	--
	\$31,058	\$35,116	\$33,018	\$32,916	\$32,853	\$41,914	\$46,739	\$38,355
DISBURSEMENTS								
Salaries & Benefits	1,914	2,613	2,117	2,475	2,821	3,105	3,385	3,850
General Expense	3,027	3,431	3,254	2,879	2,722	--	3,896	4,470
Meeting Expense	2,575	1,337	2,510	3,248	3,180	3,156	3,415	3,200
Sponsored Programs-Jrs.	8,875	8,706	10,360	9,349	10,880	10,802	11,369	11,535
Va. Journal	12,005	14,401	9,079	10,165	6,049	18,088	21,774	11,650
Committees *	1,000	3,252	2,386	1,825	2,733	3,391	2,900	3,650
Transf. to Savings & Others	762	1,376	3,312	2,975	4,468	--	--	595
	\$31,058	\$35,116	\$33,018	\$32,916	\$32,853	\$41,914	\$46,739	\$38,355
General Fund Assets 31 December	\$34,887	\$35,144	\$38,455	\$41,851	\$44,442	\$42,749	\$34,774	
Research Fund Disburse- ments	\$ 2,964	\$ 2,860 incl. above	\$ 2,000 incl. above	\$ 1,525 incl. above	\$ 2,000 incl. above	\$ 2,429 incl. above	\$ 2,600	

* Principally Research & Flora

MEMBERSHIP STATISTICS 1973-1979

Membership Begin. year	1,604	1,563	1,542	1,506	1,426	1,360	1,466
Add	156	237	176	111	93	224	240
Resign & Died	-71	-86	-62	-68	-57	-26	-49
Dropped-Non Pay.	-126	-172	-150	-123	-102	-92	-127
End of Year	1,563	1,542	1,506	1,426	1,360	1,466	1,530
Regular	1,280	1,276	1,233	1,172	1,113	1,165	1,197
Contributing	137	113	110	106	100	100	100
Sustaining	46	43	46	45	46	53	57
Student	63	73	78	61	63	113	139
Life	13	13	13	18	17	16	20
Business	24	24	26	24	21	19	17

responsible for raising about three fourths of its expenditures.

- Membership is the highest since 1975 with a resulting increase in dues income.
- On the dark side, the amount withdrawn from savings to meet the budget deficit was \$8398. This is the fifth time in 12 years there has been a deficit although the General Fund remains at about \$35,000. This is just under the amount set by Council policy of approximately one year's expenditures.
- Disbursements are the highest since 1968, due mostly to higher Journal costs coupled with an attempt to get Journal publication dates back on schedule with the required number of volumes per year. A vigorous cost reduction effort by the present Editor, Dr. Ware, has resulted in a significant reduction for the four current issues, such that the deficit of last year should not be

repeated. There will still be some deficit as a result of publishing more than 4 issues in 1980 to "catch up".

- Money available to the Research Committee for grants has increased due to rising interest rates paid on Trust funds. Contributions to this trust fund for research of several hundred dollars per year continue to be made by the membership.
- The historic ratio of VAS expenditures has been approximately equal amounts (1/3) to Jr. programs, the Journal, and all other expenses (Committees, Meeting, and Salaries). Also historically about half our income is from dues.

And now a personal note. Your chairman has asked that he be replaced after nearly a decade on this committee and 14 years on Council. You, the membership, have always responded to our calls for help, financial and otherwise and, through committees, you have been good stewards of the funds we have had. Thank

you for that help and a thank you especially to those who served with me on this committee.

The academy remains a viable and vigorous voice of science in Virginia especially to our young people because of your support as members. Keep up the good work!

D. Rae Carpenter, Jr., Chairman

Flora Committee

The Flora Committee met on May 15, 1980. Those present, including visitors, discussed their work on taxonomic treatments of various plant groups. Dr. L. M. Hill presented his survey on herbarium resources and botanists in Virginia. It will be included in the next issue of *Jeffersonia*, Volume 11 (2). Dr. Gwynn Ramsey has completed writing of the text of the brochure on careers and avocations in botany. The committee is seeking suitable photographs to illustrate the brochure. Three cost estimates for printing it were obtained: (1) 5000 copies for \$400, (2) 1000 copies for \$220-240, (3) 2500 copies $8\frac{1}{2} \times 14$ " printed on both sides with pictures and folded for \$175-200. Suggested possible sources of money were VAS Finance Committee, Sigma Xi, Forest Product Resource Companies, etc. Dr. Gustav Hall will have his proposed priority listing of threatened and/or endangered plants ready for discussion at the November, 1980, Flora Committee meeting. Dr. Ware noted that there are two plants occurring in Virginia, *Betulauber*, round-leaved birch, and *Panax quinquefolium*, ginseng, that are on the Federal list of protected plants. There was no report on sources of botanical literature.

The Flora Committee agreed to cooperate again with the Botany section in continuing liaison with the Science Teachers Conference held in the fall of each year. The topic this year is "Why Man Explores", Mr. Joseph Exline of the State Department of Education will be contacted in regard to this.

Jeffersonia Volume 10(1) has been issued. Dr. Rex Baird has updated and computerized the mailing list. The Department of Plant Pathology and Physiology, VPI & SU, was most helpful in getting this issue out. The Flora Committee is very grateful for this assistance.

Dispersment of \$150 to Dr. Martin C. Mathes for Louise Mozingo's project on woody flora at the College of William and Mary and of \$100 to Dr. L. W. Hill for his work on *Sisyrinchium* was approved by the Committee. The balance in the Flora Committee account after paying the above amounts is \$229.30.

Martha K. Roane, Chairman

Membership Committee

The work of the Membership Committee continued in much the same fashion that it did during the past three or four years. It is satisfying to be able to report that at the end of the 1979 calendar year the membership had increased by 64 members over the previous year and had increased 104 over the enrollment of four years ago. As of January 1, 1980 the total enrollment was 1,530 (Table I). It appears that the decreasing

membership trend has been reversed and it is hoped that the present trend will be continued.

Two groups were contacted by letter asking that membership be applied for. One of these was the group of people whose names appeared in the program of the annual meeting who were found not to be members. Letters were sent to 455 of these people. The second group were 281 people whose names appeared in the VAS Visiting Scientists Program who were not members of the Academy. These people were asked to add their support to the Academy by becoming members. Copies of these letters were attached.

The Academy brochure was revised and a new supply was made available through the office of the Executive Secretary-Treasurer. A new supply of application forms was also secured. A printout of the addresses of the membership by section was requested to be sent to each section chairman for his use in screening for prospective members.

Application blanks and brochures were distributed to as many persons as requested them.

The current status of the membership is not known for certain. It is hoped that the 1980-81 membership committee will be at least as successful in attracting members as the 1979-80 committee has been.

Warwick R. West, Jr., Chairman

Publication Committee

The Committee wishes to commend the efforts of the editor of the *Virginia Journal of Science*, Dr. Stewart A. Ware, in his attempts to return the publication schedule to a current basis and to maintain publications cost within the guidelines proposed by Council.

In order to have sufficient material for each issue, it is important that each member of the Academy consider submission of items for publication.

The Report of the Editor is reproduced here.

"My official responsibilities as editor of Vol. 30 of the *Virginia Journal of Science* began 18 months ago in November 1978, but my active term as editor for Vol. 30 did not begin until 7 months ago in October 1979, when the last issue of Vol. 29 was printed by the previous editor. A new printer is being used now, and printing costs are more manageable. In the last seven months we have printed the first and second issues of Vol. 30 (both carrying advertising, thanks to Business Manager Frank Kizer); gotten the combined issues 3 and 4 of Vol. 30 to the printer; and we've also gotten the combined first and second issues of Vol. 31 to the printer. Both of those should be mailed out this summer. Thus, by the time the Proceedings Issue for 1980, (which will be Vol. 31, #4) comes out in the winter of 1980 the *Journal* should be back on schedule.

The editor wishes to express his appreciation to Business Manager Frank Kizer, former President Ulrich, Publications Committee Chairman Wise, President Remsburg, and all the members of the Publications Committee and the Council for their patience and support during this period of difficulty."

John H. Wise, Chairman

Research Committee

During the past year, six research proposals were funded with a total of \$2,585. There are two proposals now under consideration. Decisions regarding these will be made within the next month.

With the resignation of Dr. Herbert McKennis, Jr., as Chairman of the Research Committee in February, 1980, only three committee members remain active. They are William L. Mengebier, Dept. of Biology, Bridgewater College, Paul B. Siegel, Dept. of Poultry Science, VPI & SU, and Stuart B. Monroe, Dept. of Chemistry, Randolph Macon College. In spite of his lack of experience with V.A.S. activities, in general, and Research Committee business, in particular, Monroe assumed the position of Committee Chairman near the first of March, 1980. Since Monroe will be on sabbatical leave from R-M.C., Beginning in February, 1981, another chairman will need to be appointed prior to the usual time of administrative changes in the Spring of 1981.

In previous years, there have been five persons, including the chairman, on the Research Committee. Since the resignation of McKennis, there have been only three active members. Therefore, two additional members should be appointed before the committee resumes its duties of screening research proposals. (Question: Must all members of the committee necessarily be selected from faculties of colleges and universities?) It is imperative that active membership on the Research Committee be brought back to five persons, so that these proposals may receive due consideration.

There were only three papers submitted in competition for the 1980 J. Shelton Horsley Award. The papers were reviewed by the Sigma Xi Chapter of West Virginia University, and the winning paper will be announced on Thursday evening, May 15, 1980. The co-authors of this paper will each receive a certificate and a check for \$250.

Members of VAS, who seek financial support of their research in the form of small grants (viz., less than \$500), should contact:

Stuart B. Monroe
Department of Chemistry
Randolph-Macon College
Ashland, Virginia 23005
Phone: 804-798-8372, Ext. 246

This reporter expresses his appreciation to Vera Remsburg, Blanton Bruner and Frank Leftwich for their help in connection with Research Committee activities since March 1, 1980.

Stuart B. Monroe, Chairman

Ad Hoc Committee to Plan Science Advisory System

The past year has been a year of dormancy for many of the ideas and activities of the Science Advisory Committee. However, as is frequently the case, following a period of dormancy comes renewed vigor and growth. Current activities at the Governor's Cabinet Level and the Legislative Committee Level of state

government indicates renewed interest in broadening support for and expanded services of a Science and Technology Advisory System in Virginia.

The recent approval by the General Assembly of financial support for a Virginia Resource Information System (VARIS) is a culmination of eighteen months of study and recommendations by the Executive Task Force and the Legislative Subcommittee. A number of the members of the Virginia Academy made significant contributions to the task force report.

Suggested Constitution and By-laws changes to establish a standing Science Advisory Committee have been approved by the membership at the Academy Conference May 15, 1980.

Ertle Thompson, Chairman

Ad Hoc Committee on Science Education

During the past year the ad Hoc Committee on Science Education, in cooperation with the College of William and Mary, Departments of Geology and of Education (Christopher Newport College) co-sponsored a graduate course offering at the 17th Annual Virginia State Teachers Conference.

The Meeting was held at Virginia Beach, VA, October 5, 6, 1979. Twenty-five teachers participated in the special course in earth science: Geology-Marine Science, and nineteen participants successfully completed all requirements for the graduate credit offering.

Plans are under way to continue cooperation with the State Department of Education-Science Service and the Virginia Association of Science Teachers to bring another program to fruition at the 18th Annual Virginia State Science Teachers Conference to be held at Fredericksburg, VA, fall 1980.

In addition to these regular and on-going committee activities, the ad Hoc Committee on Science Education was asked to review and select two high school seniors (and two alternates) to represent the Commonwealth of Virginia at the 1980 National Science and Mathematics Summer Camp (held in West Virginia each year). Selections were made on a consensus of Committee members' review of approximately three dozen submitted applications.

As previously reported, and acted upon by Council, November 11, 1979, the ad Hoc Committee on Science Education formulated a response to Mr. Wayland Jones, State Department of Education, on the matter of recommendations for material to be considered in the matter of certification regulations for science and mathematics teachers, Commonwealth of Virginia.

Virginia C. Ellet
Arthur W. Burke, Jr.
Co-chairmen

Visiting Scientists Program

Work on the 1979-1980 V.A.S. Visiting Scientist Program began in early 1979, with the securing of permission to conduct the program in the secondary schools of the Commonwealth. During April and May

of 1979 commitments were obtained from presidents of colleges and universities in Virginia to pay transportation expenses of faculty members who would be invited to give lectures under the Visiting Scientist Program. Positive responses came from 35 institutions, resulting in a Speaker's List containing over 600 scientists with approximately 1000 lecture topics.

The Speaker's List was mailed to 366 public and private schools and 130 science departments in com-

munity colleges in August. Each mailing also included the V.A.S. brochure and a membership application form. In late 1979 the list was sent to each participating speaker. Those participants who are not members of the Academy were provided with a membership form and were urged to join.

Only 25 report-of-visit forms have been received during this academic year, with audience size ranging from 11 to 150.

Abstracts of Papers Agricultural Sciences

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

METACARPAL AND METATARSAL CHARACTERISTICS OF SOWS AS INFLUENCED BY RESTRICTED GROWTH RATE AND ELEVATED MINERAL LEVELS. S. R. Arthur, H. R. Thomas, J. W. Knight, H. P. Veit, E. A. Barczewski, D. R. Notter, K. E. Webb, Jr. and E. T. Kornegay. VPI & SU, Blacksburg, VA 24061

Gilts in this study had previously been fed one of two levels of energy, ad libitum and 75% ad libitum, and one of two levels of calcium and phosphorus, 100 or 150% NRC, from weaning to 100 kg after which they all received a balanced gestation-lactation diet. Initially three groups of 65 gilts each were selected for the reproductive study. Gilts that failed to display heat, conceive after three matings or became lame during the study were slaughtered. Metacarpals and metatarsals were removed at slaughter, and were weighed, measured and tested for breaking strength, ether extract and ash content. Increasing the mineral level to 150% of the NRC standards produced a metatarsal with thicker ($P < .05$) walls with a resultant greater ($P < .05$) breaking strength, but thickness and breaking strength of the metacarpal was not different between mineral levels. Ether extract content of the metatarsal was lower ($P < .05$) for gilts fed 150% NRC minerals, but the ether extract content of metacarpals was not affected by the mineral level. Energy levels had little effect on the various metacarpal and metatarsal parameters. A comparison of metacarpal and metatarsal parameters revealed that metatarsals were longer and heavier than the metacarpals, but the metacarpals had greater strength. This study will continue for three parties.

FLEXURAL STRENGTH OF ANIMAL BONE. J.L. Baker* and J.H. Wilson*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The evaluation of metabolic or endocrine changes in the diet of an animal are incomplete without information as to how the physical properties of bone change. Bone is an important tissue component of the animal body making up 18% of the body as compared to 43% for muscle, 25% skin and fat, 11% for viscera and 3% for nervous tissue. The mechanical properties of bone are determined by the same methods used in studying similar properties of metal, woods, and other structural materials.

One of the most widely used tests of the mechanical properties of bone has been the bending test of a single supported, centrally loaded bone (three-point bending test). Specimens are either bone sections or whole bones. Simple bending test have been used in a variety of experiments. A review of the literature has been conducted and several other tests have been done to correlate a series of data for flexural strength of animal bone. The strength of large animal leg bones (bovine, equine) are similar to that of the adult human femora (11 GPa vs 15 GPa). In addition, tests of bone in bending have revealed that the assumption of negligible shear is invalid. Many data sets reported in the literature may be inaccurate due to this assumption and flexural strength may be reduced.

EFFECTS OF EARLY NUTRITION ON REPRODUCTIVE PERFORMANCE AND FOOT CHARACTERISTICS OF FIRST PARITY SOWS. R. A. Barczewski, H. R. Thomas, S. R. Arthur, J. W. Knight, H. P. Veit, D. R. Notter and E. T. Kornegay. Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061 and Tidewater Research and Continuing Education Center, Suffolk, VA 23437

The effect of restricted energy and elevated Ca and P levels during growth and development on subsequent feet and leg characteristics and reproductive performance were studied. Feet and leg measurements were taken at weaning. Reproductive data was collected before and after farrowing. Only data from the first parity is included.

Ad libitum-fed sows had wider toes on the hind foot than restricted-fed sows, with no energy effects on the front toes. Total pigs born and the number of pigs alive at 7, 14 and 21 days were decreased when the 150% NRC Ca and P levels were used in combination with ad libitum-fed sows. Pigs farrowed from sows previously fed the 150% Ca and P levels were heavier; however, this difference may be explained by slightly smaller litter sizes. Gilts that had previously been restricted-fed weighed less after farrowing and at weaning than the ad libitum-fed gilts. These results are preliminary and the study is continuing.

EFFECT OF BREED COMPOSITION ON YEARLING WEIGHT OF BEEF HEIFERS. Elizabeth T. Barnes and Thomas J. Marlowe. Dept. of Animal Science, VPI&SU, Blacksburg, Va. 24061

Heifer data from a cooperative cattle breeding project with the VA Dept. of Corrections for 1970-75 calf crops at Southampton Correctional Farm (SHCF) and 1973-75 crops at State Farm (SF) were analyzed by L.S. procedures to determine sire breed effect on performance. Sources of V included year, sire breed, year x breed, dam's age and heifer's age. Measurement traits (MT) included ADG, WDA from Wn to 12 and 18 mos, and wt, grade and cond at both ages for 207 and 197 heifers at SHCF and 419 and 369 heifers at SF at 12 and 18 mos, respectively. Breed of sire and year accounted for significant sources of V at both locations in all MT. All crossbreds (XB) outgrew straightbred (SB) controls at both locations. At SHCF, Angus (AS) heifers grew .15 lb per day slower than Hol x Ang or Char x Ang heifers and weighed 49 lb and 74 lb less at 12 and 69 lb and 108 lb at 18 mos. Diff between XB types was 25 lb and 39 lb at 12 and 18 mos in favor of Char x Ang heifers. At SF all XB heifers outgrew the SB Hereford controls by 21% at 12 mo and 12% at 18 mos except Her x Ang. Avg wt of XB's at 12 and 18 mos was 3 lb and 27 lb heavier at 12 and 18 mos, respectively, than the controls. Diff between the best XB and SB controls was 27 lb and 79 lb at 12 and 18 mos. Rank of the heifers by sire breed (H to L) based on 18 mos wt was Simmental (644), Holstein (623), Charolais (597), Brown Swiss (588), Short-horn (584), Angus (565), and Hereford (518).

RAPID PRODUCTION OF CYLINDROCLADIUM CROTALARIAE MICROSCLEROTIA. J. A. Barron and P. M. Phipps*, Dept. of Plant Pathology & Physiol., VPI & SU, Blacksburg, VA 24061.

Cylindrocladium crotalariae incites a serious disease of peanut (*Arachis hypogaea* L.) in Virginia. Microsclerotia (ms) of the fungus are preferentially used as inoculum in studies of this disease in the laboratory and greenhouse. A procedure that ensures rapid and economical production of ms is presented here. A medium for culturing ms was prepared that contained: K_2HPO_4 , 1.0 g; $MgSO_4$, 0.5 g; KCl , 0.5 g; dextrose, 100.0 g; casein hydrolysate, 0.05 g; agar, 20.0 g; dist. H_2O , 1 liter; and 1.0 ml of a micronutrient solution that supplied 0.05 mg Mn^{2+} , 0.2 mg Zn^{2+} , and 0.1 mg Fe^{3+} . The pH was adjusted to 6.5 and the medium was autoclaved (1.05 kg/cm² for 0.25 h), poured into 9 cm Petri dishes (25 ml/plate), and allowed to solidify. A mycelial suspension consisting of two ten-day-old potato-dextrose agar (PDA) cultures of *C. crotalariae* blended for 1 min in 300 ml sterile H_2O was prepared. Each plate of medium was inoculated by transferring 50 ml of suspension to the agar surface, then incubated in darkness at 25 °C. After 4 wk, cultures were comminuted for 2 min in a blender and the ms were collected on a 38 μ m sieve. The ms obtained (ca. 80,000/plate) germinated on PDA at a level of 85% after 30 h and appeared morphologically similar to those found in the root cortex of *C. crotalariae*-infected peanut plants. Peanut plants grown in raw field soil infested with these ms (30g soil) exhibited severe disease after 8 wk in greenhouse tests.

MECHANICS OF THE ANALYSES OF BEEF CALVES' GROWTH AS AFFECTED BY RALGRO IMPLANTS AND BY CROSSBREEDING. K. P. Bovard and J. S. Copenhaver, Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061

Weights in pounds from 151 beef calves at birth, in July and in September were examined in a series of least squares (LS) analyses. The data were classified in two years, 1978 and 1979; two sexes, female and steer; two breeds of dam, Shorthorn and crossbred; two breeds of sire, Hereford and crossbred, and, four classes of Ralgro implant, a growth stimulant, namely none, one at birth, one in July, and finally one at birth and one in July. In particular, the effect of adjusting for age differences between main classes was examined. Using October weight as an example, with a mean of 520 lb, the observed standard deviation was 72.0, whereas the standard error from the LS analysis, fitting for all main effects and four two-way interactions but ignoring age, was 66.3; including age in the same LS analysis further reduced the standard error to 50.7. The R^2 values for the former LS analysis was .225; that for the latter was .551. Calves from Shorthorn dams had adjusted July weights of 313.6 lb while those from crossbred dams weighed 345.4 lb. But the latter class was 9.0 days older than the former. The observed difference of 31.8 lb ($P < .002$) was reduced to 12.6 lb ($P < .07$) when adjusted for this age difference. Other relationships were similarly affected.

SIMULATION MODELS FOR CROP DRYING. C. L. Butts* J. P. Harner† J. L. Baker‡ D. H. Vaughan, A. J. Lambert*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

Before actual testing of different crop drying methods are done on a large scale, the drying process should be modeled to determine its feasibility.

Several computer programs were obtained from various sources which model the drying process for different drying methods. Because of increasing energy costs, the method of particular interest for Virginia was low temperature drying. These models were adapted for interactive use on the computer system at Virginia Polytechnic Institute and State University. The programs were run using weather data for the last fifteen years for four geographic locations in Virginia. The locations used were: Appomattox, Richmond, Norfolk and Roanoke, Virginia.

The study shows weather conditions which are favorable for low temperature drying in Virginia. It was also determined that low temperature drying can be utilized in Virginia for grain at moisture contents below 20 percent without spoilage occurring. Drying from 20 percent down to a typical safe storage moisture content of about 15 percent or below can be accomplished in less than three weeks.

CGA72662 AS A TOPICAL AND FEEDTHROUGH POULTRY MANURE TREATMENT FOR HOUSE FLY CONTROL. Andrew F. Beck*, Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, VA. 24061

A 10% emulsifiable formulation of Ciba-Geigy CGA72662, a triazine insect growth inhibitor, was applied topically to poultry manure in a commercial caged-layer, shallow-pit house at the following final dosages/200 ft² of manure surface: 0.1% (1 gal), 0.1% (2 gal), 0.05% (1 gal) and 0.05% (2 gal). Manure samples were collected prior to treatment and for 4 consecutive weeks, and emerging adult house flies/dry weight of manure sample were recorded. All treatments showed inhibition of house fly development for 4 wk.

A 3.0% premix of CGA72662 was diluted to 1.5 ppm in a standard layer diet and fed to 4 batteries of 5 birds each for 7 days. Four similar batteries were left untreated. A manure sample from each battery was collected daily from one wk prior to treatment until one wk after the end of treatment, at which time all samples were seeded with 50 first instar house flies. The manure of treated birds showed virtually total inhibition of house fly development lasting no more than 24 h after treatment, and there was no effect on the number of eggs produced by the birds or the birds' feed intake or weight gain.

SUPPLEMENTAL BIOTIN FOR SWINE. II. FOOT CHARACTERIZATION. K. L. Bryant, J. W. Knight and E. T. Kornegay. Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061

Three trials using 80 crossbred gilts per trial were conducted to evaluate 220 ug/kg of supplemental biotin to corn-soybean meal diets for growing-finishing gilts. It was previously reported that daily gain, daily feed intake, feed per gain, hair scores and structural soundness scores were not altered by biotin supplementation. Classification of all foot lesions were obtained initially and at 45 and 100 kg body weight. Heel and toe erosion and heel cracks were observed frequently across both treatment groups. Heel bruises were noted less frequently. There was a linear increase ($P < .01$) in the incidence and severity of all foot lesions as the gilts increased in body weight. Less than 2% of the gilts had heel-sole junction lesions, toe lesions, or side wall lesions and these were not related to dietary biotin level. Supplemental biotin had no effect on heel and toe erosion or heel bruising; however, the severity of heel cracks was reduced ($P < .05$) by biotin supplementation. There also was a trend ($P < .10$) for reduced incidence of heel cracks when biotin was supplemented. These results suggest the biotin supplementation may reduce the incidence and severity of foot lesions, especially heel cracks, without improving feedlot performance.

UTILIZATION OF FEET AND LEG CHARACTERISTICS AND 16 mm MOTION PICTURE PHOTOGRAPHY GAIT ANALYSIS AS POSSIBLE PREDICTORS OF SOUNDNESS IN BREEDING GILTS. D. F. Calabotta, H. R. Thomas, J. W. Knight, D. R. Notter, M. E. Wright, H. P. Veit and E. T. Kornegay. Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061

Models for structural soundness were ascertained utilizing various feet and leg parameters and gait measurements taken from 16 mm motion picture photography. At 50 and 100 kg body weight, 288 gilts were measured for the various parameters. All variables were then subjected to a backwards elimination-stepwise procedure using committee soundness scores from the appropriate time period, as the dependent variable. At 50 kg, the best model ($R^2 = .39$) revealed that a large percent horn and hind leg circumference, large inside hoof volume, sloping pasterns, high hoof elevation and gait which were long in duration, all favored desirable soundness scores. Conversely, long metacarpals, large outside front toe areas and large lateral tail movements were undesirable. At 100 kg, the most desirable model ($R^2 = .28$) included large inside and outside toes on both the front and hind legs and sloping pasterns. The best model at 50 kg which could be used to predict desirable structural soundness at 100 kg ($R^2 = .30$) included large horn percent, small metatarsals in relation to tibias, large feet, a long stride and rear legs which did not greatly deviate at the hock joint. It was concluded that the larger type hog at 50 kg generally had a tendency toward unsoundness at 100 kilograms.

BIONOMICS OF THE NORTH AMERICAN AND EUROPEAN OLD HOUSE BORER *Hyliotrupes bajulus* (L.) (Cerambycidae: Coleoptera). K. F. Cannon, Dept. of Entomology, VPI&SU, Blacksburg, VA. 24061.

The old house borer, *Hyliotrupes bajulus* (L.), is a serious structural pest in Eastern North America. The larvae of this Cerambycid can survive and feed for up to 10 years in seasoned softwood. Since its introduction into the U.S. over 100 years ago, little work has been done on the biology of the North American biotype. This study provides a biological comparison between laboratory colonies of the N.A. biotype and the European biotype.

Results obtained from this study indicate that the mean number of days spent in the prepupal and pupal stages were not significantly different between biotypes. Comparison of adult longevity and size indicate significant differences in size and longevity between sexes but not between biotypes. There was no significant difference in the mean number of eggs, mean length and width of eggs and the mean number of days required for eclosion.

AUTOCORRELATIONS IN FEEDING BEHAVIOR. G.F. Barbato* and J.A. Cherry. Dept. of Poultry Science, V.P.I. and S.U., Blacksburg, Va. 24061.

The consumption of feedstuffs does not occur at random. Instead, there is usually a specific sequence of behavioral responses to food related stimuli. Most statistical tests assume temporal independence and do not account for motivational factors, which, in turn, increases the complexity of analyzing patterns of feed intake. To account for temporal sequencing, we have adapted time series analyses, or more specifically, autocorrelation functions, to explain some of the variation in the feeding behavior of four populations of chickens. While divergent selection for body weight did not appear to alter the 24 hour feeding rhythms of chickens maintained on continuous light, the sex-linked dwarfing gene, *dw*, attenuated the cycle, suggesting a more random pattern of feed intake.

EFFECTS OF A GROWTH STIMULANT AND CROSSBREEDING ON SUCKLING BEEF CALVES. J. S. Copenhaver and K. P. Bovard. Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061.

A total of 151 calves was included in the study, with 83 born in 1978; 68 born in 1979. About half of the dams were straight-bred Shorthorns, the balance were of mixed crossbreeding among Angus, Hereford and Shorthorn. Half of the sires used were Hereford; the balance were Simmental-Hereford crosses. Calves were assigned in nearly equal numbers to four different combinations of a growth stimulant called Ralgro, as follows: Class zero served as a control with no implant; class one received a single 36 mg Ralgro implant in July, at about 120 days of age; class two received a 36 mg implant at birth; and class three received two 36 mg implants, first one at birth and one at about 120 days. A least squares analysis fitting for year, sex, dambreed, sirebreed, Ralgro and days of age showed no statistically significant effects of Ralgro on July or October weights. October weight for class three, receiving two implants, was 528 lb, 18.5 lb more ($P < .07$) than classes one and two, that received single implants. Calves from crossbred dams were 13 lb heavier in July ($P < .07$) than those from Shorthorn cows. In October the difference increased to 26 lb ($P < .03$). Calves by crossbred sires were 15 lb heavier in July ($P < .03$) than those by Hereford sires. In October, the difference decreased to 14 lb ($P < .11$).

Effects of exogenous progesterone and estrone on conceptus development, steroid concentrations and farrowing parameters in swine. D. Lee Dalton and James W. Knight, Dept. of Animal Science, VPI&SU, Blacksburg 24061.

Gilts administered progesterone (P, .55 mg/kg) and estrone (E, .275 mg/kg) during early gestation were either hysterectomized (HX) at day 50 of gestation and numerous measurements of conceptus (placenta, fetus, fetal fluids) development taken or allowed to farrow. In trial 1, HX gilts receiving P/E 20-30 (days of gestation) had longer and heavier ($P < .01$) placentas (PL) compared with gilts receiving P/E 4-20 and controls receiving corn oil (CO) 4-30. In trial 1 farrowing group, total pigs born (TPB) was not different among treatments, although live pigs born (LPB) was lower ($P < .05$) in the P/E 4-20 vs CO 4-30 gilts. In trial 2, P/E 12-20 treated gilts had larger ($P < .01$) PL at HX vs controls (CO 4-20). In trial 2 gilts farrowed, PL weight at birth ($P < .01$), TPB and LPB were also greater in P/E 12-20 gilts. At HX in trial 3, P/E 25-30 gilts had larger ($P < .01$) PL vs P/E 20-25 or CO 20-30. However, in trial 3 farrowed gilts, LPB was greater ($P < .05$) in P/E 20-25 gilts than in P/E 25-30 or CO 20-30. Other results obtained from HX gilts included an overall uterine artery minus uterine vein P difference of approximately 2.0 ng/ml (suggesting conceptus utilization of P); no trt. or sex of fetus effect on either P or total protein content of either allantoic or amniotic fluid; and higher mineral levels in the dried fetuses of treated vs control gilts.

INFLUENCE OF *PSUEDOMONAS SOLANACEARUM* AND *GLOBODERA SOLANACEARUM* ON THE GROWTH OF TOBACCO. W. H. Elmer*, J. B. Jones*, and L. I. Miller, Dept. of Plant Pathology & Physiology, Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

The influence of *Pseudomonas solanacearum* (PS) and *Globodera solanacearum* (GS) on the growth of 'VA Gold' flue-cured tobacco was studied in the greenhouse. The treatments included PS, GS, PS + GS and Control (no PS or GS). One hundred nematode cysts were introduced into GS and PS-free soil in 10.5 cm pots containing a 2:1 mixture of expanded shale-silt loam in all GS and PS + GS treatments. A single 2-month-old tobacco seedling was then transplanted to each pot of all the treatments and grown at 23-27°C. The soil of pots in which plants had grown for 3 wks in PS and PS + GS treatments was drench-inoculated with a 100 ml suspension of 10^6 bacteria/ml. Eight wks after transplanting the plant height, floral development and number of new female nematodes formed was recorded. Plants in the control treatment were in full bloom and were 4 times taller than plants in GS and PS + GS treatments in which no blooming occurred. Plants in PS treatments were 3 times taller than GS and PS + GS treatments and had a few blooms, but they were significantly shorter than plants in the Control treatment. There was a 10 fold increase in the number of nematodes in both GS and PS + GS treatments and the plants in these treatments were not significantly different in growth. The reason as to why plants in the PS treatment were smaller than in the Control is not known since no symptoms of Granville wilt of the tobacco were observed.

AN ECONOMIC INVESTIGATION OF FEEDER PIG PRICE FORMATION IN VIRGINIA. P. Fisher*, K. H. Baum, S. T. Buccola*, Dept. of Agricultural Economics, VPI & SU, Blacksburg, Va., 24061.

Preliminary investigation of feeder pig price formation in Virginia auction markets during 1975 to 1978 has indicated a number of interesting economic phenomena. Data collected included lot size, weight, grade, price per cwt., date of sale, location, tail docking, order of sale, and other relevant characteristics. Price comparisons by weight and season and by grade and weight were developed through statistical and econometric analysis. Although the highest pig prices and the lowest sale weights occur in mid-spring, the economic rationale for this is not yet apparent. Cost analysis and price summaries indicate that in most market situations, pigs can be grown from 50 to 65 pounds with larger profits than if sold at 40 pounds. Limited resource farmers might be able to increase incomes by becoming aware of seasonal pig price fluctuations and factors influencing differences in feeder pig prices.

MORPHOLOGY OF MALES OF FOUR ISOLATES OF HETERODERA SCHACHTII. Lorraine S. Graney and L. I. Miller. Dept. of Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

A comparison was made of the intraspecific variation of several morphological characters of males of isolates of *Heterodera schachtii* from New York (N) and Florida (F) with cabbage as the host plant and from California (C) and Michigan (M) with sugar beet as the host plant. Measurements (in μm) of 30-40 males of the four isolates were as follows. Body length: N 1075 - 1375 (mean 1201, standard deviation ± 87.0), M 1075 - 1425 (1241 ± 100.0), C 1038 - 1450 (1240 ± 109.7), M 1275 - 1575 (1402 ± 86.0). Stylet length: N 27.0 - 29.0 (28.0 ± 0.6), F 28.0 - 30.0 (29.1 ± 0.8), C 27.0 - 30.0 (28.3 ± 0.7), M 28.0 - 31.0 (29.5 ± 0.7). Dorsal gland orifice to stylet base: N 3.0 - 5.4 (4.2 ± 0.6), F 2.5 - 6.0 (4.1 ± 0.9), C 3.0 - 6.0 (4.8 ± 0.8), M 2.5 - 5.0 (4.0 ± 0.7). Excretory pore to head end: N 128.0 - 171.0 (151.7 ± 9.8), F 139.0 - 182.0 (162.9 ± 12.4), C 130.0 - 189.0 (162.4 ± 14.0), M 148.0 - 201.5 (173.4 ± 12.8). Tail length: N 4.5 - 9.0 (7.3 ± 1.5), F 4.0 - 12.0 (7.3 ± 1.9), C 6.0 - 10.0 (8.3 ± 1.2), M 5.0 - 11.5 (8.0 ± 1.8). Tail terminus length: N 2.0 - 5.3 (3.5 ± 0.8), F 3.0 - 7.0 (3.7 ± 0.8), C 3.0 - 6.0 (4.1 ± 0.9), M 2.0 - 5.0 (3.8 ± 0.8). Spicule length: N 29.0 - 33.0 (30.8 ± 1.4), F 29.0 - 36.0 (32.5 ± 1.8), C 30.2 - 37.0 (33.3 ± 1.5), M 31.0 - 37.5 (33.9 ± 1.7). Dimensions measured for the four isolates overlap and they overlap with published measurements of *H. glycines*.

SIX YEAR GROWTH RESPONSE OF NORTHERN HARDWOODS TO CUTTING TREATMENTS. E. J. Green*. Biometrics Sect., Dept. Forestry Va. Polytechnic Inst., Blacksburg, VA 24061.

In 1977, a study was performed on the six-year growth response of northern hardwoods to cutting treatments. The experiment, located in central New York, consisted of 4 treatments; retention of 0, 30, 60, and 90 ft. of basal area per acre on one acre plots. These were applied in a randomized block design to 4 four-acre blocks (sites). Additionally, on half of each acre plot, the understorey was removed, while on the other it was left intact.

Analysis of six-year growth data revealed that overstorey stems in the stands cut to 30 ft. had responded to release with significantly higher net basal area growth percents than stands cut to 60 or 90 ft.

Analysis of understorey data confirmed that the number of saplings was inversely related to overstorey basal area. There were more saplings on the better site. Shade intolerant white ash displayed a benefit from understorey removal, while other species did not.

HETEROSIS FROM CROSSES AMONG BRITISH BREEDS OF BEEF CATTLE: STRAIGHTBRED VERSUS CROSBRED COWS. J. M. Hagerbaumer*, J. A. Gaines, R. C. Carter, W. H. McClure and W. T. Butts*. Animal Science Dept., VPI & SU, Blacksburg, VA 24060 and U.S.D.A.

Longevity of cow, weaning wt. of calf, weaning grade of calf, percentages of calves born alive and of calves weaned, average calf age at weaning and kg. of calf produced per cow year were evaluated in a 7-year phase of a crossbreeding experiment involving straightbred Angus, Herefords, and Short-horns and all three-way cross calves from F₁ dams. Crossbred cows were studied by comparing reciprocal crosses. Generally speaking, the averages for crossbred cows were higher than those of straightbred cows for all traits. Crossbred calves had heavier weaning wts. and higher weaning grades than straightbred calves ($P < .0001$). Calves sired by Angus bulls and out of S x H crosses ranked first for weaning wt. and weaning grade. Differences in offspring from reciprocal cross dams indicated strong maternal effects on weaning performance. A significant sex x cow cross interaction for weaning weight suggested differences between the reciprocal cow crosses in their ability to respond to the larger growth potential and increased requirements of steer calves. Estimates of hybrid vigor for both weaning wt. and weaning grade were lowest for calves having Hereford maternal grand-sires and highest for calves having Hereford maternal grand-dams. Cows with Hereford dams appeared to be the preferred F₁ combination for a breeding herd.

CIRCADIAN FEED INTAKE PATTERNS IN DIVERSE GENETIC LINES OF MICE. E.A. Gerken*, W.E. Wyatt*, D.R. Notter* and H.J. Gerken*. Dept. of Animal Science, Va. Polytechnic Inst. and St. Univ., Blacksburg, VA 24061.

Twenty-four growing mice from four genotypic lines selected for high activity (AH), low activity (AL), high serum cholesterol (CH) and high weight (WH) were fed a laboratory ration *ad libitum*. At 45 days of age nine hourly feed intakes observations were obtained between 8 a.m. and 5 p.m. Mean hourly intakes for AH, AL, CH and WH, respectively, were .087, .054, .089 and .119 g/hr. As expected, WH mice consumed more feed ($P < .05$), having nearly twice the hourly feed intake of AL mice. AH and CH mice were intermediate in feed intake to the other lines. A second set of 24 hourly observations of feed intake was obtained when mice were 66 days old. During the 24 hr period, mice were subjected to 12 hr of light and 12 hr of darkness. Overall mean hourly intakes for AH, AL, CH and WH, respectively, were .246, .243, .244 and .320 g/hr ($P < .05$). For AH, AL, CH and WH, means for the 12 hr of light were .169, .144, .138 and .183 g/hr and means for the 12 hr of darkness were .330, .350, .361 and .468 g/hr. Effects of time of day on feed intake were significant at both ages. The increase in feed intake during darkness indicated an increase in eating activity for all lines during these hours. Also, the change from dark to light appeared to stimulate feed intake. The interaction between line and time of day was significant and indicated that selection had altered the pattern of feed intake.

SOIL-TILLAGE TOOL INTERACTION STUDIES AT VIRGINIA TECH R. Grisso* and J. Perumpral*, Dept. of Agricultural Engineering, Va. Polytechnic Inst., Blacksburg, VA 24061.

Information on the factors effecting and their influence on the performance of a tillage tool is essential for designing more efficient tools. At Va. Tech, approximately three years ago a research program to study the soil-tillage tool interaction was initiated. The objective of this project is to develop generalized mathematical model/s which include all pertinent soil and tool parameters to predict the performance of a tillage tool.

Both for developing a clear understanding on the soil-tool interaction and for the experimental verification of the models, a soil-bin test facility was designed and constructed. The facility consist of a stationary bin, soil processing carriage, tool carriage, and a hydrostatic drive system. The stationary bin is approximately 10 meters long, 1 m wide and .3 m deep and was constructed of .35 cm sheet metal. The soil processing carriage includes a rotary tiller, strike-off blade and a teflon coated roller to prepare the test section prior to tests. The tool carriage includes a tool positioning assembly and a six-degree-of-freedom dynamometer capable of measuring three dimensional forces and moments on the tool. A servo controlled hydrostatic drive system is used to power the tool carriage. Test speeds in the range of 0 - 10 km/hr. with different acceleration and deceleration rates are possible with the drive system. (Aided by NSF grant).

RELATIONSHIP OF Ca AND K CONCENTRATIONS IN PEANUT SEED TO GERMINATION. D. L. Hallock and J. L. Steele*, Va. Polytechnic Inst. and S. U. and USDA, SEA, Tidewater Res. and Cont. Educ. Ctr., Suffolk, VA 23437.

Low Ca contents in peanut seed may affect germination. Interference of cations such as K with Ca absorption by fruit may reduce germinability. The relationship between the concentrations of these cations in the seed and viability was investigated in four experiments in which seed had developed in varied nutrient environments.

In two Ca-source experiments in 1977 and 1978, the correlation coefficients for the relationship of germinability versus seed Ca were 0.40** and 0.45** and versus seed K were -0.08 and -0.43**, respectively. Ca concentrations in the seed ranged from ca 270 to 620 ppm (447 in 1978) and seed K from ca 0.70 to 0.90%. Seed germination varied from 76 to 98% in 1977 and from 56 to 85% in 1978.

Correlation coefficients obtained in two other nutrition experiments in 1978 for germinability versus seed Ca were 0.46** and 0.66**, and versus seed K were -0.37** and -0.30**. In the latter studies, seed Ca ranged from ca 300 to 675 ppm, and seed K from ca 0.70 to 0.90%, and seed germination from 35 to 85%.

Production practices which decrease K and increase Ca concentrations in seed may enhance germinability and vice versa. (Aided by Va. Agr. Fdn. grant).

STATE OF THE ART OF SOLAR ENERGY FOR CROP DRYING. J.P.

Harner*, C.L. Butts*, D.H. Vaughan, J.L. Baker*, and A.J. Lambert*. Agricultural Engineering Department, Seitz Hall, VPI&SU, Blacksburg, Va. 24061.

On-farm crop drying in 1974 required approximately 107×10^{12} Btu's of energy, or the equivalent of nearly 1.21×10^9 gallons of LP gas. In Virginia approximately 2.26×10^{12} Btu's (2.52×10^7 gallons of LP gas) were used for drying in 1977.

Solar energy has been used in many on-farm crop drying processes, such as for drying corn, peanuts, tobacco, rice, and other crops. The three types of solar collectors normally used are bare plate, covered plate, and suspended plate designs. The bare plate and covered plate designs are the most common for on-farm crop drying. For solar crop drying, air is moved through the collector and then directly to the drying facility. This direct use of the energy eliminates the need for an energy storage facility, which is not economical in most drying systems at present energy prices. Solar heat can increase the drying temperature five to ten degrees, which is adequate for low temperature drying in Virginia in most cases. The pay-back period for the solar collector decreases as the number of different crops dried increases, or as the use period during the year increases. The pay-back period for most systems is less than seven years, while the life of the solar collectors may be as long as twenty-five years, depending on the kinds of materials used.

PREDICTION OF EROSION FROM STRIP MINE SPOIL USING THE UNIVERSAL SOIL LOSS EQUATION (USLE). E. L. Hockman, Jr.*, V. O. Shanholzt and J.N. Jones*, Dept. of Ag. Engr., Va. Polytech. and State Univ., Blacksburg, VA 24061

Sixteen field plots were located on an active "Mountain Top Removal" mining operation located near Beckley, WV. Each plot was instrumented to measure precipitation, surface runoff and soil loss. Cover percentages and soil erodibilities were also determined. Erosion predictions were then made for each plot using the USLE and the Onstad Modified USLE.

Preliminary results of statistical analysis on accumulated data from storm events from June 4, 1979 to October 3, 1979 indicate both models provided inaccurate estimates of soil loss. For slopes less than 20% no consistent error pattern existed. Estimates for these slopes were significantly less than and greater than the actual value measurement. On slopes greater than 20% the model's predictions were always significantly greater than measured soil loss.

The sediment loads measured from the field plots ranged from .0001 tons/acre for .4 inches of rainfall to 1.4896 tons/acre for 1.53 inches of rainfall.

AN EVALUATION OF INCOME RISK ASSOCIATED WITH VIRGINIA SWINE PRODUCTION SYSTEMS. L. Johnson*, K. H. Baum, Dept. of Agricultural Economics, VPI & SU, Blacksburg, Va. 24061

Swine production in Virginia has become an increasingly important source of income for many Virginia farmers. The choice and level of production of feeder pigs, fat hogs or a complete farrow-to-finish operation and crops can be a critical decision for producer financial stability. In this analysis, a MOTAD (income deviation) analysis of the risk and economic impact of these enterprises were evaluated for a typical farm in the Virginia Tidewater area. A high income level specification selected the farrow-to-finish system as the optimum choice. At lower income levels, feeder pig and finishing enterprises competed with alfalfa hay and corn to minimize income risk. The low income deviation level for the feeder pig system demonstrated its attractiveness to risk adverse producers willing to sacrifice the opportunity for higher incomes.

GROWTH OF WEANLING LAMBS RECEIVING THREE DIFFERENT STARTER RATIONS. Nancy Heininger, William H. McClure and Elizabeth T. Barnes, VPI&SU, Blacksburg, Va. 24061, and Southern Seminary Junior College, Buena Vista, Va. 24416

Lamb data from a cooperative lamb rearing project between Southern Seminary Junior College, Buena Vista, and Shenandoah Valley Research Station, Steeles Tavern, were analyzed by L.S. procedure of the Statistical Analysis System. Twelve lambs were assigned to six pens. Lambs were fed milk replacer individually to 20 lbs and allowed alfalfa hay and water free choice during the three-week test period.

Two models were used to analyze weight gain and feed consumption. Sources of V included ration, sex, regression on initial weight, and regression on total milk and ration, sex, regression on initial weight, for Models I and II, respectively.

For Model I only ration and total milk in week I ($P < .05$) for weight gain and ration in week II ($P < .01$) for feed consumed were significant. For Model II initial weights were significant ($P < .05$) for all weeks.

A TECHNIQUE FOR THE RECOVERY OF STAND STRUCTURE FROM WHOLE STAND YIELD FORECASTS. D.M. Hyink*, Dept. of Forestry, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Mathematically, two classic forest growth and yield forecasting techniques are related by: $N \int_{d_1}^{d_2} g_1(x)p(x)dx = Y_1$, in which $p(x)$ is a k parameter probability density function characterizing the distribution of tree diameters at breast height (dbh), $g_1(x)$ is a function relating dbh to a tree attribute such as volume or weight, N is the total number of trees per acre and Y_1 is the yield per acre for $g_1(x)$ applied to all trees in the interval bounded by d_1 and d_2 . Under the diameter distribution approach, the g_1 , $j=1, k$, are predicted as functions of stand age (A), site index (S), and number of stems per acre (N); and the Y_1 's computed as $NE[g_1(x)]$. Conversely, under a whole stand approach, the Y_1 's are predicted directly as functions of A, S and N, but no distributional information is available. Presented are two techniques that may provide reasonable first approximations to underlying diameter distributions solely from the results of these whole stand models. If a system of k linearly independent equations, $NE[g_j(x)] - Y_j = F_k(\theta) = 0$, $i=1, k$ exists, they may be solved simultaneously for the k parameters, θ . Alternatively, if m such equations exist ($m > k$), we may find the k parameters, θ , that minimize $F_m(\theta)^2 = (NE[g_j(x)] - Y_j)^2$, $i=1, m$. In certain cases, the latter method may degenerate to the former.

USE OF PEANUT HULLS IN SOYBEAN PRODUCTION. G. D. Jones* and R. B. Reneau, Jr., Piedmont Research Station, VPI & SU, Orange, Virginia 22960 and Department of Agronomy, VPI & SU, Blacksburg, Virginia 24061.

Peanut (*Arachis hypogaea* L.) hulls are a waste product that have potential for increasing soybean (Glycine max (L.) Merrill) yields when recycled to agricultural land as a source of nutrients and as a mulching material. This study was conducted to determine if peanut hulls could be applied at disposal rates and simultaneously increase soybean yields as a result of increased nutrients and moisture in the rooting zone of certain acid soils. Peanut hulls were applied to a Tatum (Typic Hapludult, clayey, mixed, thermic) silt loam soil at rates of 0, 21, 42 and 84 $\times 10^3$ kg/ha on fertilized and unfertilized plots. In 1977 a year of moisture stress peanut hulls increased the yield of seed by 500 kg/ha and forage by 1,560 kg/ha as a result of increased plant available moisture in the fertilized plots. In the unfertilized plots each 1000 kg/ha of hulls produced 21 kg/ha of seeds. In 1978 a year of more optimum conditions 50×10^3 kg/ha of hulls were required to equal yields produced with fertilizer application.

INFLUENCE OF A MAMMOTH CHARACTER ON THE PERFORMANCE OF FLUE-CURED TOBACCO (*NICOTIANA TABACUM* L.). J. L. Jones

and T. R. Terrill, Southern Piedmont Center, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 23824.

The mammoth gene causes otherwise day-neutral *Nicotiana tabacum* to flower only under short photo periods. Two day-neutral cultivars of flue-cured tobacco (Speight G-28 and NC 2326) and their mammoth counterparts were evaluated in field studies in 1979. Leaf number of the mammoth lines was adjusted by removing four bottom leaves and leaving four additional upper leaves to give the same number of harvested leaves as the day-neutral cultivars. Mammoth NC 2326 produced significantly higher yields, a higher quality index, lower total alkaloids, and less priming (P) grades than its day-neutral NC 2326 counterpart. In contrast, Mammoth Speight G-28 gave a lower yield and otherwise performed similarly to conventional Speight G-28.

Age associated changes in swine articular cartilage. G. A. Kesell*, James W. Knight, H. P. Veit, and E. T. Korngay. Virginia Polytechnic Institute and State University, Blacksburg

Crossbred boars were euthanized at 10 + 2 days from 80-220 days of age (inclusive) to characterize selected biochemical changes in articular cartilage (AC) associated with age. Total joint surface AC obtained from the distal end of the femur (F) and humerus (H) and proximal end of the radius-ulna (R-U) was characterized following acetone drying. Hydroxyproline (HYP) was measured to indicate collagen content and uronic acid (UA) was measured to indicate total chondroitin sulfate. HYP increased with age. Mean HYP values for boars 80-100 and 220 days of age, respectively, were 71.8 vs 77.3, 72.3 vs 77.0 and 71.8 vs 75.2 mg/g for the F, H and R-U, respectively. Levels of UA in the F decreased between 80-100 (80.2 mg/g) and 220 days of age (76.5 mg/g), while UA in the H and R-U did not differ with age. Results suggest that the collagen content of AC increases and total chondroitin sulfate decreases with age.

NORTHERN CORN ROOTWORM LARVAL CONTROL IN FIELD CORN IN VIRGINIA, 1978. B. C. Kondratieff* and J. E. Roberts, Sr., Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The test was conducted in Montgomery Co., Va., from Jun-Jul '78. Three rates of San 326 (5G) and San 6626 (5G) were compared to Furadan 10G and an untreated control. San 326 and San 6626 are code name products of Sandoz, Inc. Test plots measured 75 feet and consisted of 4 rows in the planted field. Treatments were replicated four times in a randomized complete block design. Furadan was applied in the furrow, in a 7-inch band at planting time. San 326 and San 6626 were applied two days later in a band over the row and lightly incorporated into the soil. Larval damage was assessed on Jul 26 by digging and washing 10 root systems from each replication. Root systems were evaluated using a standard 1-6 rating where 1=little or no damage and 6=3 or more nodes of roots destroyed.

There was no significant difference between treatments at the 0.05 level of significance using the Duncan Multiple Range Test. In the course of evaluation average ECB damage was recorded.

CORN ROOTWORM CONTROL ON FIELD CORN IN VIRGINIA, 1979. B. C. Kondratieff* and J. E. Roberts, Sr., Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Corn was planted (May 10/79) in Montgomery Co., Va., to evaluate planting time applications of eight granular insecticides for the control of corn rootworm larva. Treatments were applied in a 7-inch band over the row in front of the presswheel. The experiment was arranged in a randomized complete block design with four replications. Plots for each treatment consisted of four rows 50 feet long on 36-inch centers. Root damage was determined by digging and washing 6 plants on Jul 11/79 from each row. Treatments were evaluated by root damage ratings (Iowa 1-6 system). Data was analyzed using Duncan's Multiple Range Test. The soil type was silt loam. The field had a history of Furadan use. Rain-fall for May, June and July was above normal. Air temperature for the period was below normal.

Few northern or southern corn rootworm adults were observed in the field. No significant differences were observed between treatments. No phytotoxicity was evident.

BLACK CUTWORM CONTROL IN NO-TILL FIELD CORN IN VIRGINIA, 1979. B. C. Kondratieff* and J. E. Roberts, Sr., Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Lorsban 4E^R, Orthene 75S^R and Pennap MR 2F were applied using techniques that simulate present equipment methods for control of black cutworm. Corn was planted in small grain stubble on Apr 15/79 in two fields located in Bedford Co., Va. Light weed growth was observed in both fields. Field 1 was planted using 'Pioneer 3147' and field 2 with 'Dekalb 72-B'. The tests (experiments) consisted of plots measuring 14' x by 50' (4 rows) replicated four times in a randomized complete block design.

Insecticide treatments were evaluated by counting the number of cut plants per row. Cut plants were removed because some cut seedlings survive and regrow. Both fields had heavy pretreatment black cutworm infestations with cutting pressure averaging 20%.

Cutworm activity was significantly reduced compared with untreated areas, however, none of the treatments provided 100% control. Orthene 75S and Lorsban 4E gave the best consistent control of black cutworm larvae. No chemical phytotoxicity was observed.

FALL ARMYWORM CONTROL ON FIELD CORN IN VIRGINIA, 1979. B. C. Kondratieff* and J. E. Roberts, Sr., Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Eight insecticides were compared for effectiveness in control of fall armyworm. Field corn was planted June 22/79 in Goochland Co., Va. Treatments were arranged in a randomized complete block design with four replicates. Four row plots measured 50 feet by 12 feet in which the two center rows were used for analysis. All insecticides were applied using a 4-gallon hand held sprayer operating at 40 psi and a rate of 20 gallons per acre. Granular materials were applied in a 7-inch band over the whorl. Treatments were applied July 26 and insect counts made 1 and 3 days post-treatment. Numbers of small (instars 1-3) and large (instars 4-6) larvae per plant were determined on each sampling date. Plants were selected at random and sacrificed to ensure proper counting of larvae. Data was analyzed using Duncan's Multiple Range Test. Soil association was Conagree-Chewada. The field had a history of Furadan use.

The fall armyworm infestation was high (100%) in this field with 1st and 5th instar larvae present when insecticides were applied. Lannate and the three Larvin 500 rates gave good control. All other materials gave intermediate to poor control. None of the materials were phytotoxic.

CONTROL OF THE POTATO LEAPHOPPER IN VIRGINIA, 1979. B. C. Kondratieff and J. E. Roberts, Sr., Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

At the VPI & SU Animal Science Farm in Montgomery Co., Va. three rates of Orthene 75S and 1 rate of Sevin 80% WP were applied to plots tested for control of the potato leafhopper on a four year old planting of alfalfa in the "second-cutting" growth stage (approximately 16 inches tall, 5% bloom). Plots 20 ft. long by 20 ft. wide, were arranged in a randomized complete block design, and replicated four times. Insecticides were applied with a hand-carried four gallon compressed air sprayer calibrated to apply 108 gallons of water per acre at 50 psi. Pretreatment and post-treatment insect counts were taken using a 15-inch diameter sweep net making 10 pendular sweeps per plot. Post-treatment insect counts were taken 3 and 5 days after treatment.

The alfalfa did not exhibit any phytotoxic effects after treatment. All three rates of Orthene 75S and Sevin 80WP were effective against the potato leafhopper with only light hopper burn being observed at the study site.

TRUE ARMYWORM CONTROL ON FIELD CORN IN VIRGINIA, 1979. B. C. Kondratieff and J. E. Roberts, Sr., Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Five insecticides were applied and evaluated for control of armyworm in Augusta Co., Va. Funks 5757 variety corn was planted May 1/79 using a randomized complete block design. Four row plots, 50 feet in length were replicated four times. Pretreatment population counts (number of plants with larvae) were obtained representing 200 feet of row replicated twice. Pretreatment population counts indicated 100% infestation. The two center rows of each plot were used for evaluating treatments. Treatments were applied May 30 using a compressed air sprayer operating at 30 psi spraying 73 gallons per acre and a hand cranked duster to apply granular materials in a 6-inch band. Post-treatment counts were obtained on June 1 and June 3 by counting the number of larvae alive or dead per plot. Armyworm larvae were in their second to fourth instar.

Data indicated that the treatments were all significantly different from the untreated check at the 0.05 level of significance using dead larvae as criteria. Lannate (.45 lbs ai/acre) was the most effective of the five insecticides evaluated. The other materials listed in order of effectiveness are Dyfonate 20G (3.75 lbs/A), Dyfonate 20G (5 lbs/A), Pennpac M (1 lb ai/A) and Pennpac M (0.5 lbs ai/acre).

OATS IN STARTER DIETS FOR WEANED PIGS. E. T. Kornegay and K. L. Bryant, Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061.

Four trials, using 138 weaned pigs initially weighing 5.4 kg, were conducted to compare the performance of pigs fed a basal starter diet containing zero or 10% ground whole oats. Average final weight of pigs was 18.2 kilograms. Pigs were housed in environmentally controlled triple deck nurseries. A 22% corn-soybean meal diet with 10% dried whole whey was ad libitum fed until average pen weight was 7 kg; then a 20% protein diet was fed to 11 kg; an 18% protein diet without the whey was fed for the remainder of the test.

Daily gain, daily feed intake and feed per gain were not different between pigs fed starter diets with zero or 10% oats during any weekly period and over the entire trial. Fecal firmness and cleanliness scores were not different between pigs fed diets with and without oats. Diarrhea was not a problem in these studies and no deaths occurred.

Daily gain was similar for pigs housed on all decks; however, contrary to previous reports, feed intake and feed per gain was slightly higher for pigs housed on the bottom deck compared to pigs housed on the top and middle decks. Cleanliness scores indicated that the pigs housed on the lower decks became more soiled as the study progressed.

The addition of 10% ground oats to a corn-soybean meal starter diet did not alter feedlot performance. Diarrhea was not a problem and no deaths occurred.

A SURVEY OF VIRGINIA PEACH ORCHARDS FOR PEACH STEM PITTING AND ASSOCIATED NEMATODES. L. K. Kroll* and J. A. Fox*, Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, VA.

Two to five problem orchards/county in 10 Virginia peach growing counties were surveyed between August 1978-June 1979 to assess the incidence and severity of Prunus Stem Pitting (PSP). The age of diseased trees, origin of planting stock, orchard locale, and presence of other diseases and PSP virus weed hosts were recorded. Soil was sampled from PSP diseased trees, trees with other diseases, and healthy trees and assayed for nematodes using the sugar flotation-centrifugation extraction technique. PSP was found in 8 of 10 counties and in 25% of the orchards. The incidence of diseased or dead trees ranged from 1-12%. Although no correlation between PSP and tree age, origin of planting stock, orchard locale, or other diseases was found, PSP was often associated with stress factors such as winter injury, borer damage, mechanical injury, drought, or weed problems. The nematode vector *Xiphinema americanum* was present in 94% of the samples and several PSP virus weed hosts were present in all orchards. *Xiphinema americanum* and *Helicotylenchus* sp. populations were significantly higher near PSP diseased trees than healthy trees. In summary, it appears that: (1) PSP is a widespread problem in VA peach orchards, (2) the nematode vector and weed hosts of the virus are not limiting factors to disease spread, and (3) PSP is often associated with various stress factors including high *Xiphinema americanum* and *Helicotylenchus* sp. populations.

EFFECTS OF RALGRO IMPLANTS ON GROWTH RATE AND CARCASS CHARACTERISTICS IN BEEF CATTLE. W. O. Lamm, R. F. Kelly and J. P. Fontenot. Depts. of Animal and Food Science, Virginia Polytechnic Institute, Blacksburg, Va. 24061.

In trial 1, steer and heifer calves were implanted at birth with 0, 12, 24 or 36 mg zeranol. Implanted calves were reimplanted with 36 mg at approximately 100 days of age. Daily gain from birth to weaning was similar for implanted calves compared to control calves. In trial 2, bull and heifer calves were implanted at birth or 100 days of age with 0 or 36 mg zeranol. Implanted calves were reimplanted with 36 mg every 100 days until a minimum of 65 days prior to slaughter. Adjusted weaning weights tended to be higher for implanted heifers compared to unimplanted heifers while bulls implanted at birth weighed less than unimplanted bulls or those implanted at 100 days of age. In the growing-finishing phase, unimplanted bulls gained faster ($P < .05$) than implanted bulls. Heifers gained similarly regardless of implant treatment. Heifers implanted first at 100 days of age had more desirable yield grades than heifers receiving the other treatments. In trial 3, bull and heifer calves were implanted at birth with 0 or 36 mg zeranol. Implanted calves were reimplanted with 36 mg every 100 days until a minimum of 65 days prior to slaughter. Implanted heifers weighed more ($P < .01$) while implanted bulls weighed the same as unimplanted heifers and bulls, respectively, at weaning. During the growing-finishing phase, implanted bulls and heifers gained faster ($P < .10$) than their unimplanted counterparts. Carcasses of implanted calves had more desirable cutability than unimplanted calves.

A QUICK AND EASY METHOD FOR ESTIMATING VOLUME IN LOBLOBBY PINE PLANTATIONS. R. C. Lemin*, R. M. Hyink*, Dept. of Forestry, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

For forest stands in which the variability in height of individual trees is small, it is shown that the consequences of horizontal point sampling in combination with a special type of constant form factor tree volume equation result in estimates of stand volume requiring only an enumeration of the sample trees. Two illustrations of this "ametric" (without measure) technique are given for plantation grown loblolly pine. In the first, cubic foot volume is estimated from stem count, site index and stand age. A second alternative relies upon stem count and mean stand height.

THE EFFICACY OF KABAT® FOR CONTROL OF THE CIGARETTE BEETLE UNDER SEVERE INFESTATION CONDITIONS. J. S. Long; R. M. Lehman; M. H. Tickle; and M. A. Manzelli. Philip Morris Research Center, Richmond, VA 23261.

KABAT®, also known as ALTOSTIP®, was evaluated for control of the cigarette beetle under conditions of severe infestation. A total of ten thousand adult cigarette beetles were placed into each of eight hogheads, located in a miniwarehouse, during May to September, 1978. In early August, 1979, counts were made of the number of adults trapped in each of the hogheads. Over 12,000 adults were trapped in two control hogheads (one strip, and one stem) and only six adults in the six hogheads (three strip and three stem) treated with KABAT®. The KABAT® treatment was successful in preventing larvae of the cigarette beetle from completing their life cycle and continuing to reinfest the commodity.

EFFECT OF BREED COMPOSITION ON YEARLING WEIGHT OF BEEF STEERS, Thomas J. Marlowe and Elizabeth T. Barnes. Dept. of Animal Science, VPI&SU, Blacksburg, Va. 24061

Steer data from a cooperative cattle breeding project with the VA Dept. of Corrections for 1970-75 calf crops at Southampton Correctional Farm (SHCF) and 1972-75 crops at State Farm (SF) were analyzed by L.S. procedures to determine sire breed effect on performance. Sources of V included year, breed, yr x br, dam's age and animal age, plus mgt and yr x mgt in SHCF data. Measurement traits (MT) included ADG and WDA from Wn to 12 and 18 mos, and wt, grade and cond at both ages for 233 and 213 steers at SHCF and 512 and 336 steers at SF at 12 and 18 mos, respectively. All sources acc for signif V in all MT, except age of dam on ADG at 12 mo and ADG, WDA and wt at 18 mo at SF and grade and cond at SHCF. All crossbreds (XB) outgrew straightbred (SB) controls at both locations. At SHCF, Angus (AA) steers grew about 1/4 lb/day slower than Hol x Ang or Char x Ang steers and weighed 54 and 82 lb less at 12 mo and 89 and 117 less at 18 mo. Diff between XB types was 28 lb at both ages in favor of Char x Angus steers.

At SF all XB steers outgrew the SB Hereford controls by an ave of 36%. Ave wt of XB's at 12 and 18 mo was 56 lb (14.8%) and 71 lb (12.7%) heavier, respectively, than SB controls. Diff in best XB and SB controls was 131 lb (23.4%). Rank of XB's (H to L) by sire breed based on 18 mo wt was Holstein (690), Shorthorn (660), Simmental (640), Charolais (622), Angus and B. Swiss (tied, 584) and Hereford (559).

A MATHEMATICAL MODEL OF A BATCH-TYPE CROP DRYER. F.F. Massie*, D.H. Vaughan, and A.J. Lambert*. Dept. of Agricultural Engineering, VPI & SU, Blacksburg, Va. 24061.

Recent price increases and shortages of fossil fuels have caused farmers to become more aware of the energy used in crop processing. On-farm processing often wastes large amounts of energy due to overdrying and inefficient drying. One possible method of increasing drying efficiency is the partial recirculation of drying air.

Recirculation of the drying air has good potential in peanut drying because water removal is only a part of the curing process. The water must be removed from the crop at a relatively slow rate to maintain good milling quality and flavor. Yet, it must be fast enough to prevent mold formation. Recirculated drying air should have a higher relative humidity than daytime solar heated air. In typical batch drying processes recirculated air should help prevent overdrying where the air enters the peanuts. To establish the best air recirculation procedures, a mathematical model is needed to predict the state of the drying air.

In developing a model, the interior of a drying shed can be considered a partially controlled volume. The psychrometric state of the air at any time inside the controlled volume can be predicted if the initial state is known, the heat additions and losses are known, and the moisture additions and losses are known. Once the state of the controlled volume air is known, the drying potential of the drying air can be estimated.

FEEDING TESTS OF CEUTORHYNCHUS TRIMACULATUS, A POTENTIAL BIOLOGICAL CONTROL AGENT OF THISTLES. T. J. McAvoy* and L. T. Kok. Dept. of Entomology, VPI & SU, Blacksburg, VA 24061

Ceutorhynchus trimaculatus F. is a thistle-rose tte feeding weevil found in the Caucasus, mediterranean region and in parts of Central Europe. Its known hosts are thistles of the subtribe Carduinae. It was imported from Italy under quarantine for host specificity testing in Blacksburg, Virginia in 1976. As a potential biological control agent of *Carduus* thistles, it is necessary to determine whether it poses a threat to desirable or economic plants in the U.S.A. Feeding tests showed that it was able to complete development from the first instar to the adult stage on only 3 out of 27 host plants tested: *Carduus nutans* L. (musk thistle), *C. acanthoides* L. (plumeless thistle) and *Cirsium vulgare* (Savi) Tenore (bull thistle). A fourth plant, *Cynara scolymus* L. (artichoke) yielded one adult out of 225 first instars and was poorly suited to larval development. Musk, plumeless and bull thistle, *Silybum marianum* (L.) Gaertn (milk thistle), *Cirsium arvense* (Canada thistle), *Cirsium discolor* (two-colored thistle) and artichoke supported oogenesis but *Cardhamus tinctorius* L. (safflower) did not. Oviposition rate dropped sharply when adults were switched from musk thistle to artichoke. Significantly more eggs were laid on the thistles than on artichoke. Results of the tests indicate that *C. trimaculatus* is sufficiently host specific on the target weeds.

PRELIMINARY EVALUATION OF A PRACTICAL SAMPLING METHOD FOR ESTIMATING ORIU INSIDIOSUS (SAY) POPULATIONS ON APPLE TREES. J. P. McCaffrey, M. P. Parrella, and R. L. Horsburgh. Dept. of Entomology, VPI & SU, Shenandoah Valley Res. Sta., Steelton, VA. 24476.

The anthorcid bug, *Orius insidiosus* is a important polyphagous predator in Virginia apple orchards. The most frequently used method of sampling *O. insidiosus* populations is tapping limbs over a cloth covered tray. The dislodged bugs are then counted. While efficient, this sampling technique is time consuming and damaging to tree limbs and fruit. The purpose of this study was to investigate the potential for relating, by regression, population estimates obtained by a simpler, less-damaging, but less efficient, visual timed search to the population estimates obtained by limb-tapping.

Our results indicate that population estimates obtained by a visual search are related to those obtained by limb-beating. Also, the results indicate that further studies should be directed towards evaluating the sampling method for each development stage (i.e., nymph vs. adult) of the bug.

SEASONAL ABUNDANCE AND SPECIES COMPOSITION OF APHIDS IN SMALL GRAINS. R. M. McPherson and J. R. Martin*. Dept. of Entomology, Va. Polytechnic Inst. and State University, Blacksburg, Va. 24061

Fluctuations in population densities of the aphid complex in small grain were directly related to weather conditions during the 1978-79 and 1979-80 seasons. Populations rapidly increased in wheat, barley, and rye during Nov.-Dec., exceeding 200 aphids/row foot. However, densities steadily declined during Jan.-Feb., when daily mean temperatures were commonly mid-30's (°F) and below. Over-night temperatures below 32 °F followed by mid-day temperatures of 50-60 °F had little effect on reducing aphid populations.

Greenbugs (GB) and corn leaf aphids (CL) were the predominant species during Nov.-Dec. In Jan., GB, CL and oat bird-cherry aphids were present in equal numbers. CL aphids rapidly declined during Feb.-March and were not in small grain in April. English grain aphids (EG) comprised only a small percentage of the complex during Nov.-Feb.; however, during March and April EG and GB were the most abundant species.

DIMENSIONS OF CYSTS AND EGGS OF FOUR ISOLATES OF *HETERODERA SCHACHTII*. L. I. Miller and Lorraine S. Graney. Dept. of Plant Path. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

A comparison was made of the dimensions of cysts and eggs of field isolates of *Heterodera schachtii* from New York (N) and Florida (F) with cabbage as the host plant and from California (C) and Michigan (M) with sugar beet as the host plant. Measurements (in μ m) of 40-90 cysts of the four isolates were as follows. Length including neck: N 565 - 1010 (mean 812.0, standard deviation \pm 97.0) F 673 - 1140 (897.0 \pm 90.0), C 664 - 942 (797.0 \pm 65.4), M 408 - 991 (716.5 \pm 109.9). Breadth: N 401 - 652 (508.1 \pm 81.9), F 370 - 594 (480.6 \pm 51.2), C 403 - 650 (516.4 \pm 55.4), M 251 - 590 (449.8 \pm 91.4). Length/breadth ratio: N 1.2 - 1.9 (1.6 \pm 0.2), F 1.5 - 2.3 (1.9 \pm 0.2), C 1.2 - 2.2 (1.6 \pm 0.2), M 0.7 - 2.4 (1.6 \pm 0.2). Measurements of 40 eggs with second-stage larvae of the isolates were as follows. Length: N 100 - 109 (105.3 \pm 2.6), F 95 - 108 (100.4 \pm 4.0), C 103 - 116 (108.1 \pm 3.7), M 95 - 118 (105.9 \pm 5.6). Breadth: N 43 - 49 (46.6 \pm 2.2), F 40 - 50 (46.3 \pm 2.2), C 38 - 55 (43.6 \pm 3.7), M 43 - 58 (48.5 \pm 3.6). Dimensions measured of the four isolates overlap and they overlap with published measurements of *H. glycines*.

THE IMPACT OF VEGETABLE GARDENING ON DIETARY INTAKES OF THE ELDERLY PEOPLE IN SOUTHSIDE VIRGINIA. S.W. Moak, Dept. of Human Ecology, Va. State Univ., Petersburg, Va. 23803

Vegetables are grown by a significant number of elderly people, and it is becoming a popular hobby. Comparative studies indicate that the number of suburban and rural vegetable gardeners were significantly higher ($p < .01$) than nongardeners. However, in urban setting, nongardeners were significantly greater than gardeners ($p < .01$). Mean energy and nutrient intakes by gardeners were generally higher than nongardeners. However, vitamin B₆, vitamin C, and iron intakes were only nutrients which were significantly different at the level of $p < .05$. Food consumption pattern of elderly gardeners showed that tomato consumption was significant at the level of $p < .01$. Green beans and potato consumptions were significantly different between the gardeners and nongardeners at $p < .05$. The gardeners consumed more varieties of the vegetables. The home grown vegetables were preserved by 70 percent of the elderly gardeners. Approximately, 25 percent of the gardeners supplemented 30 percent of their family need of vegetables. In terms of food expenditure, gardeners spent 15 percent less than the nongardeners per person per month.

EFFECT OF SEED SIZE ON THE YIELD, GRADE AND VALUE OF NC 7 PEANUT CULTIVAR. R. Walton Mazingo. Tidewater Res. and Cont. Ed. Ctr., Suffolk, Va. 23437.

Sizing peanut seed is a normal practice in the Southeast and Southwest peanut production area where Spanish and Runner type peanuts are grown. However, this has not been the normal procedure in the Virginia-Carolina production area where the large seeded Virginia type peanuts are produced. With the release of the Virginia type NC 7 cultivar, which has a high percentage of extra large kernels, seed-size warranted investigation. In this experiment the effect of six seed-sizes on yield, grade and value of the NC 7 cultivar was determined.

The peanut seed were sized as follows: all size kernels > 16/64", > 16/64" < 24/64", > 16/64" < 26/64", > 16/64" < 28/64", > 24/64" < 26/64" < 1 inch slotted screen. Seed size did not affect percent fancy pods, percent total meat, yield or value per acre significantly. There was a trend toward production of a higher percentage of extra large kernels where the larger seed were planted. Seed harvested from this experiment will be sized and further tested.

VARIABILITY OF A WET SOIL MAPPING UNIT IN GREENSVILLE COUNTY, VIRGINIA. C.D. Pascock, Jr., W.J. Edmonds, and J.G. Baker*. Department of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A complex of Aquilts and Aquepts had been mapped throughout the county, based on use and management and classification. Series names were needed to identify the complex for correlation. A random selection method was used to identify taxonomic units and establish their percentages. The study was stratified between two terraces. Strata 1 was below an elevation of 100 feet and Strata 2 was above 100 feet.

Strata 1 was very uniform with all members in the clayey, mixed, thermic family placement. Strata 1 was represented by 50 percent Aeric Ochraquults, 33 percent Aquic Hagpludults and 17 percent Typic Ochraquults. This complex is recommended to be named *Wahne Variant-Craven Variant* soils.

Strata 2 was not uniform. All members were placed in the siliceous, thermic family placement. Strata 2 was represented by 33 percent coarse-loamy Aeric Ochraquults, 17 percent coarse-loamy Typic Ochraquults, 17 percent coarse-loamy Aeric Fragiaqupts, 17 percent fine-loamy Typic Ochraquults, and 16 percent Typic Psammaqupts. The complex cannot be named at present since 50 percent of the unit has no established series.

Separate mapping units will be used for each strata or terrace.

SOIL CHEMICAL VARIATIONS IN TWO DRAINAGE CATENAS IN GREENSVILLE COUNTY, VIRGINIA. C.D. Pascock, Jr., W.J. Edmonds, and J.G. Baker*. Department of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Two drainage catenas were selected from soils with similar marine and fluvio-marine sediments to determine if relationships in pH, calcium, and the aluminum-total acidity ratio from well drained to poorly drained soils existed. Chemistry from the Soil Survey lab at Virginia Tech using 1N KCl and BaCl₂-TEA extraction was used for the selected soils.

In both catenas, the aluminum-total acidity ratio increased from a well drained soil to a poorly drained soil and also increased with increasing depth in most soils. The mean of the ratio was greater than 30 percent in all but one observation. The pH was below 5.5 in all observations and below 5.0 in most observations. Calcium decreased with depth. As the calcium decreased with depth, the aluminum-total acidity ratio increased with depth.

This study reflects a strong potential for aluminum toxicity to some plants and crops.

THE INFLUENCE OF PREPLANT SOIL INCORPORATED TRIFLURALIN AND PEBULATE ON REPRODUCTION OF *GLOBODERA SOLANACEARUM* ON TOMATO. C. L. Pirkey* and L. I. Miller. Dept. of Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

The influence of preplant soil incorporated herbicides, trifluralin (TF) and pebulate (PB) on reproduction of the cyst nematode, *Globodera solanacearum* (GS) on 'Pearson A-1' tomato, was studied in the greenhouse in Virginia. The treatments included GS + TF, GS + PB, GS, and Control (no GS, PB, or TF). One hundred cysts of GS containing about 160 eggs/cyst were introduced into a cyst-free soil in 15.2 cm pots containing a 2:1 mixture of expanded shale (Meb-lite®) - Groseclose silt loam. TF at 0.5 ppm or PB at 1.5 ppm was incorporated in the nematode infested soil. Three days after the herbicide treatments were applied, a single 2 month-old tomato seedling was transplanted to each pot of all the treatments and grown at a temperature of 23-27°C. After 3 months the soil was screened for nematode females. The number of females produced was 12 percent greater in the GS + TF treatment and 27 percent greater in the GS + PB treatment than in the GS treatment. Vine growth, as measured by dry weight, was inversely related to the number of females formed on the tomato roots. The reasons for the greater reproduction of the nematode in the herbicide treated soils is currently not known.

HYPOPIAL FORMATION IN CALOGLYPHUS BOHARTI (ACARINA: ACARIDAE). S. L. Poe and E. A. Cross*. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Experiments were performed to test the influence of environmental factors on formation of the facultative deutonymph (hypopode) of *Caloglyphus boharti* (Cross). Mites were reared at different humidities, with and without food, under crowded conditions, and in dishes with mite excretory products at 64°F, 74°F, and 84°F, to test for hypopial formation.

Food shortage is a major factor influencing hypopial formation, but the role of the other factors was not conclusively demonstrated.

SORGHUM RESPONSE TO PHOSPHORUS AND POTASSIUM APPLICATION ON A DAVIDSON SOIL. R. B. Reneau, Jr.* and G. D. Jones. Department of Agronomy, VPI & SU, Blacksburg, Virginia 24061 and Piedmont Research Station, VPI & SU, Orange, Virginia 22960.

Application of phosphorus (P) and potassium (K) are both essential for maximum production of crops. This study was conducted to determine the effect of P and K on the yield of forage sorghum (*Sorghum sudanense*) on a Davidson (Rhodic Paleudult, clayey, kaolinitic, thermic) clay loam soil. Two experiments were conducted during 1978 and 1979. One where P was applied at rates of 0, 14.7, 29.3, and 58.7 kg/ha and was split with K applications of 0 and 112 kg/ha the other where K rates of 0, 27.8, 55.8 and 112 kg/ha were the subplots and P applications of 0 and 58.7 kg/ha were the main plots. When two rates of K were applied over four rates of P yields were significantly increased with increased P application for both 1978 (from 20.5 to 31.6 metric tons/ha) and 1979 (from 15.2 to 20.7 metric tons/ha). There was a significant response to K application in 1979 (from 17.2 to 19.5 metric tons/ha) while in 1978 a year of more optimum moisture conditions no response to K application was observed. When no P was applied at each level of K, there was a decrease in yield with increased K application. The chemical composition of the plant tissue generally increased in P and Mg with increased P application. The application of K increased K concentrations, but reduced Ca and Mg concentrations as a result of ion competition.

SWINE, CONTROL OF HOG LICE ON BROOD SOWS, 1978: J. E. Roberts, Sr., and B. C. Kondratieff*, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Two tests were conducted in Buckingham Co., Va., from June '78 to Aug '78 on brood sows. Two rates of GX-118, 1:2 parts water and 1:5 parts water, were compared to pretreatment counts and untreated check animals. GX-118 contains 11.6% Prolate® (phosmet) which equals 1 lb per gallon active ingredient. Both dilutions were applied as a pour-on. Animals were treated along the backbone from the neck area to the hip area. Approximately 1 oz/cut of body weight was applied to each animal by means of a calibrated dipper.

Excellent control was obtained for a period of three weeks, using both rates. There was no evidence of adverse effects on the animals or the applicator.

THE AGRICULTURAL ECOLOGY OF INTERCROPPING. M. K. Reynolds* and R. W. Elias. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Virginia, 24061.

Agriculture and ecology have developed as two polarized sciences: one applied, the other theoretical. Both converge in the study of agroecosystems. The growing concern for world food supplies has focused attention on one such system: intercropping.

One important reason that intercrops may be successful is the intensive use of environmental resources. Different canopy levels can absorb more solar energy and CO₂, while differences in root architecture or nutrient needs can increase the use of soil resources. Other positive interactions include N₂ fixation by legumes, and decreased insect damage or weed infestation.

This study investigates the energy budgets of a maize-soybean intercrop system. Maize yields increased while soybean yields decreased, resulting in a land equivalent ratio (LER) of one. The most closely intercropped soybeans had increased leaf biomass, but decreased grain biomass. Intercropped maize had greater solar conversion efficiency earlier in the season than monocropped maize. Both effects can be explained by the amount of solar radiation intercepted.

CORN COBS VERSUS CORN STALKS: A COMPARISON OF ENERGY VALUES FOR DRYING CORN. J. K. Riggins*, A. J. Lambert*, and D. H. Vaughan. Dept. of Agricultural Engineering, VPI & SU, Blacksburg, Va. 24061.

Corn residue samples were tested as potential fuel sources for drying corn. Samples were taken during August and September, 1979 at TRCEC, Holland, Virginia. Each sample included the entire corn plant five inches above ground level. For each sample, bomb calorimeter tests were performed both on representative cob sections and representative plant sections (excluding kernels). All tests were made on a wet basis and thus reflect variations in energy as a function of moisture content. The combustion results of cob versus the entire plant were compared at different harvested kernel moisture contents to determine the practical use of each fuel, from a combustion standpoint, in drying corn.

Combustion results indicate that cobs and stalks have near identical energy values at the same moisture content and for the same weight of dry matter. However, unlike stalk energy, cob energy can be reasonably predicted as a function of kernel moisture content. Kernel moisture content cannot be used to effectively predict stalk energy since wide variations exist between stalk energy values at similar kernel moisture contents.

SWINE, SARCOPTIC MANGE CONTROL, 1979. J. E. Roberts, Sr., and B. C. Kondratieff*, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Testing was conducted in Cumberland Co., Va., during the period of Mar '79 thru June '79. Experiments evaluated Remolate (GX-118) for control of contagious sarcoptic mange. GX-118 is a code name for an 11.6% phosmet (Prolate) formulation which contains one pound of active ingredient per gallon. A 1:49 dilution was applied to six Yorkshire gilts weighing approximately 150-160 lbs. A four gallon compressed air sprayer operating at approximately 30 psi was used to apply the material. A second test was conducted as a repeat of the original. Approximately 16 ozs. of mixture was applied to each animal spraying thoroughly inside the ears, flanks and pastern areas.

In the original test and the repeat the control obtained from GX-118 was poor to fair at best. No adverse effects on animals or applicators was observed.

SWINE, HOG LOUSE CONTROL WITH ECTIBAN[®], 1979. J. E. Roberts, Sr., and B. C. Kondratieff, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Two formulations of Ectiban[®] were applied on July 17/79 to two groups of animals in a confinement barn. Each treatment consisted of 4 animals. Group I was treated manually with Ectiban 0.25% Livestock Dust or at a rate of 1 oz. per animal. Group II was treated with Ectiban 5.7% Emulsifiable Concentrate with an end concentration of 0.025% at a rate of 1 pt. per animal with a pressurized sprayer. Group III was untreated and served as the control. Treatments were applied particularly on the face, ears, neck, dorsal mid-line and approximately the dorsal half of the side. Evaluation was done by counting adult and immature lice and observing eggs.

Both spray and dust formulations were effective initially. However populations built up rapidly after 8 days. A second application at original rates resulted in complete louse control up to 30 days (termination of test). Transient scratching and rubbing was observed for several minutes after spraying and dusting. No other adverse reactions were observed.

CATTLE, FACE AND HORN FLY CONTROL ON BEEF CATTLE WITH ECTIRIN[®] EAR TAGS, 1979. J. E. Roberts, Sr., and B. C. Kondratieff, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Ectrin[®] ear tags were attached to two herds of beef cattle in June '79. The first group consisted of 44 adult Angus cows with calves. All cows were tagged in both ears on June 20/79. The second group consisted of 34 adult Hereford cows with calves and were tagged in one ear on June 21/79. Calves were not tagged. A third group of similar size, with no fly treatment, served as a control. The groups were separated by at least 2 miles. An assessment of treatment efficacy was made prior to treatment and post-treatment by inspecting 10 head selected at random from each herd at weekly intervals usually between 10-11 a.m. Face flies were counted on the entire face while horn flies were counted on both sides of the entire animal. Binoculars were used to aid counting when necessary. Data was analyzed using Duncan's Multiple Range Test.

Ectrin ear tags were very effective against the horn fly throughout the test period ($P < 0.01$). Face flies were also significantly reduced in number ($P < 0.01$). The loss of three ear tags (one ear tag per animal) occurred with the Angus herd. There was no significant difference between two or one ear tag per ear. No irritation or necrosis was noticed in the ears.

AN ECONOMETRIC MODEL OF THE VIRGINIA BEEF AND PORK INDUSTRIES: CONCEPTUAL AND STATISTICAL PROBLEMS. A. Safyurtlu,* K. H. Baum, and W. Purcell,* Dept. of Agricultural Economics, VPI & SU, Blacksburg, Va., 24060

A modified econometric model of the Virginia beef and pork subsectors has been estimated as part of a larger research effort to model Virginia agriculture. Difficult conceptual problems involving structural specification and linkage with macro models of the U.S. beef and pork sectors with impact and interim multipliers have been considered. Statistical problems arising from incomplete data series compiled by both the state and the SRS, USDA limited both the structural detail incorporated into the model, and the number of estimated variables. The econometric equations included in the model are beef cow inventory, beef cow slaughter, calf inventory, calf slaughter, sows farrowed, market hog inventory and hog slaughter. Exogenous national target variables were specified as barrow and gilt (BGP), veal (VP), and utility cow prices (CUPQ). The effects of a 1,250 million pound increase in national beef imports on the Virginia beef-pork economy were analyzed in a two-step procedure: (1) the impact of national policy on target variables (BGP, CUPQ, VP), and (2) the initial and multi-period effect of the target variables on the Virginia beef-pork sector.

INSECT AND MITE PESTS OF AZALEAS AND THEIR RESPONSE TO CONTROL MEASURES. Peter B. Schultz and Liz Ann Parnell. Virginia Truck and Ornamentals Research Station. Virginia Beach, VA 23455.

Azaleas are commonly injured by several insect and mite species. The azalea caterpillar, *Datana major*, was a major problem of azaleas in residential plantings, being first observed on August 23, 1979. Five insecticides (*Bacillus thuringiensis*, Sevin, Larvin, and Bendicarb) were tested and all were effective in controlling the larvae within 48 hours after treatment. The azalea lacebug, *Stenhanitis pyridoides*, is a pest of azaleas both in greenhouses and outdoors. Sevin, Orthene, and the synthetic pyrethroids controlled this insect. The azalea leaf miner, *Gracillaria azaleella*, and the azalea leaf tier are also found in greenhouses and outdoors. The leaf miner can be controlled by soil and foliar systemic insecticides, while leaf tier control is still being studied. The Japanese weevil is a foliage feeder that inflicted heavy damage in 1978 but was at very low levels in 1979.

The southern red mite, *Oligonychus ilicis*, remained at low levels in 1979 until late fall. In September, treatments of Kelthane, Plictran, Vendex and Omite were applied to a block of Hershey red azaleas. All treatments eliminated the infestation while the untreated block had a high mite population until the first frost.

EFFECTS OF MYZUS PERSICAE (HOMOPTERA: APHRIDIDAE), ON FLUORECURED TOBACCO YIELD, QUALITY, AND CHEMICAL COMPOSITION. P. J. Semtner. Southern Piedmont Center and Dept. of Entomology, V.P.I. & S.U., Blackstone, Va. 23824

Studies were conducted during 1978 to determine the effects of the green peach aphid, *Myzus persicae* (Sulzer), on the yield, quality, and chemical composition of fluorecured tobacco, *Nicotiana tabacum* L.

Aphid populations were adjusted in the different treatments by supplementing natural populations with artificial infestations in some treatments and by using insecticides to reduce them in others. Population estimates were made weekly for comparisons among treatments. Tobacco was harvested and yield, quality, and chemical composition, including total nitrogen, total alkaloids, and reducing sugars were determined.

Compared to the control, which had aphid populations maintained at low levels, tobacco with very high aphid populations had reductions in yield of 14 to 20%, in value/ha of 16 to 25% and in value/kg of 2 to 8%. Tobacco treated with malathion and then reinfested 5 weeks after transplanting had high aphid populations which resulted in significant reductions in yield and quality, while reinfestations at 6 weeks after transplanting did not significantly reduce tobacco yield or value.

Leaves from the third harvest (mid-stalk leaves) of heavily infested tobacco had significantly lower reducing sugars and higher total alkaloids than the control tobacco.

AN IN VIVO STUDY ON THE EFFECT OF ANCYMIDOL (A GROWTH RETARDANT) ON SOYBEAN INTERNODE ELONGATION. D. G. Shilling* and D. M. Orcutt. Dept. of Plant Pathology and Physiology, Va. Tech., Blacksburg, VA 24061.

Ancymidol and gibberellic acid (GA₃) were applied in hydronic solutions, in various concentrations and combinations, to 7 day old soybean plants (*Glycine max* L. Merr.). Growth was determined by measuring internode elongation over a 10 day period. Final fresh and dry weights of stem tissue were also obtained. Plants were maintained in a growth chamber under continuous illumination at 25°C.

Both ancymidol and GA₃ were shown to affect all 3 growth parameters, and these effects were shown to be concentration dependent. Growth was stimulated by GA₃ at all 3 concentrations tested (10⁻⁶, 10⁻⁷ and 10⁻⁸M). The degree of stimulation increased concurrently with an increase in concentration. Ancymidol inhibited growth at concentrations of 10⁻⁷, 10⁻⁸ and 10⁻⁹M, but at 10⁻⁹ and 10⁻⁸M growth was either unaffected or slightly stimulated. Ancymidol-induced growth inhibition was partially or in some cases totally alleviated by joint applications of GA₃. The addition of GA₃ also delayed the onset of ancymidol-induced inhibition of internode elongation. GA-stimulated growth was enhanced by low concentrations of ancymidol (10⁻⁹M), but the interaction was antagonistic when the concentration of ancymidol was increased. The type of ancymidol-GA interaction was therefore dependent on the concentration of the 2 chemicals.

OVERWINTERING MORTALITY OF THE ROSETTE WEEVIL, *CEUTHORHYNCHIDUS HORRIDUS*. P. J. Sieburth* and L. T. Kok. Dept. of Entomology, VPI & SU, Blacksburg, VA 24061

Ceuthorrhynchidus horridus (Panzer), a thistle rosette weevil imported from Europe for the biological control of musk thistle (*Carduus nutans*) and plumeless thistle (*Carduus acanthoides*), was tested for host specificity before it was released in Virginia in 1974. Various aspects of this weevil have been studied to find out more about its attributes and its ability to adapt to its new environment. Included are studies to ascertain how well it overwinters in southwest Virginia and to determine if overwintering is an important mortality factor. Overwintering adult weevils were placed in specially constructed field cages between November and April.

Cages (3' x 3' x 3') consisted of a wooden frame, plywood bottom, fine wire mesh on four sides and organza on the door. Soil was placed in the cages to a depth of 15cm; three musk thistle rosettes were planted in each cage during the summer. In November 6 female and 7 male weevils were added to each of 10 cages, before they were sealed shut. Weekly high and low temperatures, snowfalls and unusual weather were recorded. In April, when adult activity (feeding and mating) was observed, the cages were brought into the laboratory for counts of surviving adults. Survival rate ranged from 38.5-76.9%; no significant differences in mortality were observed between sexes.

WATER QUALITY EFFECTS OF AGRICULTURAL LAND USE. M. D. Smolen*. Dept. of Ag. Engr., Va. Polytechnic Inst., Blacksburg, VA. 24061.

Three adjacent watersheds (20 to 50 ha) in the southeastern Piedmont section of Virginia were monitored for four years to determine the water quality effects of cropping activity. Through the period of study, one of the three watersheds was maintained as a control, with no cropping activity and no chemical applications. The background condition as represented by the control watershed has extremely low inorganic nitrogen concentration (flow-weighted mean 0.026 mg/l) and has total phosphorus concentration (.059 mg/l) slightly in excess of the proposed EPA criterion level. Inorganic nitrogen concentration observed in the treated watershed ranged five to seven times higher than the control. Total nitrogen export from the treated watersheds was observed to be twice as high as the control. Total phosphorus export from the treated watersheds was three to five times higher than the control. Ammonium and nitrate nitrogen input from rainfall was less than total nitrogen export from the treated watersheds, but slightly greater than total nitrogen export from the control. A mass balance calculation indicated that 10 to 14 percent of the fertilizer nitrogen used in the treated watersheds was exported in stream flow. The corresponding estimate for phosphorus indicated that two percent of the phosphorus from fertilizer was exported.

PRODUCTION AND UTILIZATION TRENDS IN THE VIRGINIA APPLE INDUSTRY. F.J. Spinelli* and H.S. Baumes, Jr. Dept. of Agricultural Economics, Va. Polytechnic Inst., Blacksburg, VA., 24061.

The Virginia apple industry has undergone several changes over the past 40 years and is expected to continue changing in the future. This paper examines certain elements that affect production and marketing of Virginia's apple crop. A trend analysis is presented with projections to the year 2000.

Some factors examined in this paper are orchard size, numbers of orchards, location of orchards, tree density, production by variety, and utilization. It was found that orchard size is increasing and total orchard numbers declining. There will be an estimated decline of 200 growers in Virginia by the year 2000. Production from the remaining 400 orchards is expected to be primarily marketed in the processing sector. Since 1950 the percentage of the Virginia apple crop being processed has grown from 50 percent to 72 percent in 1979. If the trend continues, by the year 2000 over 90 percent of the apple crop will be processed.

SOUTHERN CORN ROOTWORM CONTROL ON PEANUTS IN SOUTHEASTERN VIRGINIA. John C. Smith, VPI&SU, TRACEC, Suffolk, VA 23437

Experiments were conducted in 1978 and 1979 at two sites in order to develop a data base for establishing a pest management program. Dyfonate® 10G @ 2.0 lb AI/acre when applied on 7/31/78 controlled the southern corn rootworm and allowed 3.3% injured peanut pods. The same chemical and rate applied on 9/1/78 allowed 19.6% injured pods. Injury in untreated controls averaged 38.7%. Values derived from grades and yields showed significant differences between treated and untreated plots. Application of Dyfonate on 8/1/79 and 8/14/79 allowed 2.4% and 9.9% injured pods, respectively. Differences in value were again significantly better than controls.

Chemical controls applied on the basis of percent injured pods, as determined by weekly survey, demonstrated no significant difference in injury or value due to treatment. Numerical differences favored treatment at the 1% level (8/16/79) followed numerically by applications at 3% and 5% on 8/29/79 and 9/3/79, respectively.

Insecticidal applications to a rootworm resistant variety (NC 6) allowed greater injury in plots treated with ineffective chemicals than in untreated plots. Dyfonate treatments were effective at 1/4, 1/2 and full rates of application.

A FORESTRY DATA BASE FOR HARVESTING CHARACTERISTICS. G. L. Somers* and R. G. Oderwald*. Dept. of Forestry, VPI&SU, Blacksburg, VA. 24061

A forestry data base is being developed to test the feasibility of bringing together information now available from the Federal Government, various state agencies, trade associations, and individual companies, and putting that information into a common, easily referenced form. The information needs of forestry equipment companies and land managing firms were identified through questionnaires, letters, comments, and conversations. Generally, the information desired concerned land form, trafficability, forest type, stocking and growth, ownership, and potential work force. The MARK IV data base management program was chosen as the central software for the project. Information is stored in the program in a layered fashion. Large scale information such as county identification, major timber types, and Forest Survey information stored on a large grid of points, with more specific information stored on a finer grid. Presently county and stocking have been stored on a 10 by 10 km grid and elevation, slope, and aspect on a 1 by 1 km grid. Information on soils, ownership, growth, and demographics is being collected to add to the data base at various levels. The base of each grid point at any level is the Universal Transverse Mercator coordinates of the point taken from a Defense Mapping Agency digital terrain tape which provides elevations and UTM coordinates for points on a 208 foot grid. Slope and aspect were also computed from these elevations.

SOURCES OF AGRICULTURAL GROWTH IN VIRGINIA. E. Lee Sprouse*, J. D. Coffey*. Department of Agricultural Economics, Virginia Polytechnic Institute and State Univ., Blacksburg, VA. 24061.

The purpose of this study was to highlight the major changes in Virginia agricultural production over a period of twenty-five years (1949-1977.) Special attention was given to the impact of changes in conventional inputs such as land, labor, and capital, and to determine the effect of new and improved technology attributable to research and extension expenditures.

These input factors were evaluated to measure the contribution of research and extension programs to agricultural production in the state for prediction purposes to determine future allocations to these programs.

HEAT RECOVERY FROM VENTILATION EXHAUST OF LIVESTOCK BUILDINGS. L.A. Stauffer*, D.H. Vaughan, and N.E. Blackwell*. Dept. of Agricultural Engineering, VPI & SU, Blacksburg, Va. 24061.

A heat pipe heat exchanger was installed with a ventilation system in a swine nursery in Blacksburg, Va. The purpose of the heat exchanger was to preheat incoming air with the heat extracted from the exhaust air. The objectives of the research were (1) to evaluate the operating performance of the heat exchanger, (2) to determine its economic feasibility, and (3) to determine how dust concentrations in the exhaust air would affect its performance and life.

A heat pipe is a passive device that uses conduction, convection, vaporization and condensation to absorb and release the latent heat of a working fluid. This two-phase system has a thermal conductance a thousand times that of copper. Since the active working fluid allows for more heat transfer per unit volume than most other heat exchangers, a relatively small unit may be used.

The heat pipe heat exchanger had an overall effectiveness of 0.53 +/- 8% and supplied 45% of the heat requirement for the swine nursery during 1979 tests. Fouling from dust was not a significant problem. The payback period for the heat recovery device is less than 5 years. (Aided by USDA grant 11-14-7001-557).

INFLUENCE OF EARLY PLANT DEVELOPMENT AND MANAGEMENT ON AGRONOMIC PERFORMANCE OF TOBACCO, *NICOTIANA TABACUM*. T. R. Terrill and J. L. Jones. VPI & SU Southern Piedmont Center, Box 448, Blackstone, Va. 23824.

Early plant development may have a direct impact on the agronomic evaluation and economic worth of any crop plant. Plant development is especially important for tobacco since the vegetative portions are marketed. Transplant treatments included initial plant size, normal and low leaf area (clipped), root condition, and storage variables. Field experiments were conducted in 1978 and 1979 to measure the impact of plant quality on growth and final production of flue-cured tobacco. A randomized complete blocks design was utilized within years. We found that initial plant size was a paramount factor which influenced tobacco production. Storage conditions also influenced plant development with cold storage superior to tobacco barn storage. Large differences were recorded for clipped plants during the early and mid-season periods, but there were no differences associated with clipping (reduced leaf area at transplanting) after mid-season. In general, very small plants and those subjected to seven days of storage showed poor growth and total productivity. The combined analysis of variance revealed highly significant year by treatment interactions for yield, value and percent survival. The interactions permit interpretation of the influence of plant quality under adverse (1978) and favorable (1979) plant establishment conditions.

FLOORING MATERIALS FOR SWINE NURSERY CAGES. H. R. Thomas and E. T. Kornegay, Tidewater Research and Continuing Education Center, VPI & SU, Suffolk, Va. 23437

Plastic coated expanded metal (9 gauge, 1.3 x 2.5 cm), galvanized woven wire (5 gauge, 1.0 x 3.8 cm) and galvanized flat expanded metal (9 gauge, 1.9 x 3.8 cm) floors were compared in two trials using 288 weaned pigs averaging 7.4 kg. Average final weight of pigs was 23.4 kg and pigs were on test an average of 42 days. Pigs were housed in an environmentally controlled triple deck nursery. A 20% protein corn-soybean meal diet with 10% dried whole whey was ad libitum fed until the average weight of pigs in a cage was 11 kg; an 18% protein dried without whey was fed afterwards. Daily gain, daily feed intake and feed efficiency were not different (P > .10) between pigs housed on the different types of floors. However, pad scores were lower (P < .05) suggesting fewer cuts, cracks and abrasions, for pigs housed in cages with plastic coated expanded metal floors as compared to pigs housed in cages with woven wire and expanded metal floors. Overall means adjusted for initial weight were respectively for plastic coated expanded metal, galvanized woven wire and galvanized expanded metal: daily gain (kg) - .37, .37 and .36; daily feed intake (kg) - .74, .74 and .72; feed per gain ratio - 1.97, 1.99 and 1.97. Pigs housed on the bottom, middle and top decks performed equally well with no apparent effects on their health and behavior.

A GOAL PROGRAMMING METHOD FOR FOREST LAND APPRAISAL. J. F. Thurmes*. Biometrics Sect., Dept. Forestry, Va. Polytechnic Institute, Blacksburg, Va. 24061.

It is difficult to appraise the fair market value of areas where forestry and agriculture do not compete directly, as forest land is rarely sold absent of stocking.

This paper presents a goal-programming method of estimating forest land value components from comparable market sales, and compares it with methods presently in use. The goal-programming method is a form of non-least squares regression which minimizes the sum of absolute deviations from the regression. Compared to least-squares regression, relatively less weight is given to those sales near the fringes of the data. This is reasonable, as the data on the fringes can be expected to provide "less valid" indications of fair market value. The goal programming model also offers flexibility to the appraiser in the relative weighting of sales.

The method performed well in an appraisal using data from Western Oregon. It provided estimates of bare land value that compare well with other analyses.

SHORT-HORNED GRASSHOPPERS IN SOUTHERN PIEDMONT FORAGE CROPS. Taylor Williams*. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Ecological sampling of grasshoppers (Orthoptera:Acrididae) was performed in ten of Virginia's piedmont counties. Results from collection in three different forage crops showed *Melanoplus f. femurrubrum* (DeGeer) to be the most important species present, both in terms of density and distribution. Other frequently encountered species included *Chortophaga viridifasciata* (DeGeer), *Dichromorpha viridis* (Scudder), *Encotolophus sordidus* (Burmeister), *Hippiscus rufus* (Scudder), *Melanoplus d. differentialis* (Thomas), and *Syrbula admirabilis* (Uhler).

SHEAR STRENGTH OF ANIMAL BONE. J.H. Wilson* and J.L. Baker. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Many researchers have measured the elastic properties of bone as a means of evaluating metabolic or endocrine reactions in animals. These evaluations are incomplete without knowledge of all the properties of bone. One such example is the shear properties of bone.

Special fractures indicating torsional (shear) loads appear in many athletes. Any attempts at fixation, therefore, must involve the installation of a fixation unit capable of surviving torsional (shear) loads. Animals used for work or pleasure (horses) also experience these same shear failures. Pure shear tests have been conducted to evaluate the ultimate shear strength of animal bones. Results indicate that the shear strength is about one-tenth of that of flexural strength. Reviews of the literature indicate that several others have found similar results for the human.

Analytical work indicates that shear can be a very important segment of the deflection in bending. If the length to diameter ratio (L/D) is less than 10, the effects of shear can not be ignored. Three point bending tests were used to show the effects of shear. Changing the L/D ratio from 9.2 to 6.2 for avian bone caused a 32% reduction in the elastic modulus when shear was neglected.

PALATABILITY AND ACCEPTABILITY OF THREE STARTER RATIONS FOR WEANLING LAMBS. Gail Woodbury, William H. McClure and Elizabeth T. Barnes, VPI&SU, Blacksburg, Va. 24061, and Southern Seminary Junior College, Buena Vista, Va. 24416

Lamb data from a cooperative lamb rearing project between Southern Seminary Junior College, Buena Vista, and Shenandoah Valley Research Station, Staebles Tavern, were analyzed by L.S. procedure of the Statistical Analysis System. Three ewe lambs and three wether lambs were assigned to two pens, respectively, and fed three rations free choice for three weeks.

In Model I, sources of V included pen (\pm sex) and ration. There were significant differences ($P < .01$) for amount of feed consumed in all weeks for ration and in week I for pen. In Model II, sources of V included pen (\pm sex) ration, week, pen x ration, pen x week. All sources accounted for significant variation.

Wethers consumed 15% more feed than the ewes ($P < .01$) LS means for daily consumption of the three rations were 1.43 lb, 2.58 \pm .08 lb, and 3.39 \pm .08 lb.

A GREENHOUSE METHOD FOR TESTING FUNGICIDE ACTIVITY AGAINST MONILINIA BLOSSOM BLIGHT OF PEACHES. K. S. Yoder, Dept. of Plant Pathology & Physiology, VPI & SU Fruit Research Laboratory, Winchester, VA 22601

A laboratory and greenhouse method was developed to assay fungicide activity against Monilinia blossom blight of peaches. Freshly-opened blossoms treated in the field are selected and excised from shoots and placed on moist sand in plastic dishes containing 5-20 blossoms per dish. Inoculum of Monilinia fructicola is grown on potato-dextrose agar and uniformly atomized onto the excised blossoms as a water suspension containing 25,000 conidia per ml. Blossoms treated in the laboratory are treated prior to inoculation by misting the diluted test material onto the blossoms to the run-off point with an atomizer. Immediately after inoculation the replicated units are placed in a moist chamber (100% RH) at 21°C. After a five-day incubation period the percent discolored area is estimated as an indicator of fungal colonization. Sporulation of blighted petals is evaluated by suspending the petals in a measured volume of water and counting the resulting conidial suspension with a hemacytometer.

COMPARATIVE EFFECTIVENESS OF RPAR FUNGICIDES AND ALTERNATIVE FUNGICIDES FOR APPLE DISEASE CONTROL. K. S. Yoder, Dept. of Plant Pathology & Physiology, VPI & SU Fruit Research Laboratory, Winchester, VA 22601

Standard apple fungicides benomyl, captan, folpet, mancozeb, metiram, and zineb, currently under RPAR (Rebutable Presumption Against Registration) consideration by EPA, were compared to non-RPAR alternatives dodine + sulfur, ferbam and thiram for control of fruit and foliage diseases and for fruit finish on mature 'Delicious', 'Golden Delicious', and 'Rome Beauty' apple trees. Recommended rates of the diluted materials were applied to replicated single-tree plots with a high pressure single nozzle handgun. Thiram provided acceptable fruit finish, but was significantly weaker on control of scab, rust, sooty blotch, fly speck and Brooks spot than several of the RPAR fungicides recommended for control of these diseases. Ferbam provided acceptable control of scab and rust on foliage and Brooks spot on fruit, but did not adequately control scab, sooty blotch and fly speck on fruit. Ferbam also significantly roughened the fruit finish of the 'Rome Beauty' cultivar. The dodine + sulfur combination provided adequate control of scab and did not disturb the fruit finish, but the combination did not adequately control Brooks spot, sooty blotch and fly speck, particularly on 'Golden Delicious'. Mancozeb provided outstanding overall disease control and fruit finish on all cultivars. Captan and metiram significantly improved the finish of 'Golden Delicious' compared to untreated fruit.

ECONOMIC INJURY LEVEL FOR COCKROACH PEST MANAGEMENT PROGRAMS. P. A. Zungoli*, and W. H. Robinson.* Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The pest management concept can be adapted to urban settings to minimize pesticide usage for household pests. It may be helpful to urban pest management programs to establish an injury level for important pests.

A survey of public housing residents was conducted in Baltimore, MD, Norfolk, VA, and Roanoke, VA in July and August, 1979. The survey objective was to determine attitudes and level of knowledge of public housing residents toward cockroaches. Survey results indicate that it may not be possible to establish an "economic" or "aesthetic" injury level for urban pest management programs. Eighty-five percent of the 649 residents questioned felt that cockroaches were a serious problem, and 48% felt that seeing even 2 cockroaches would be a problem. These same residents spent an average of \$23.00 over a six-month period supplementing public housing operated pest control with store-purchased insecticides, and in some cases, professional pest control services.

A COMPATIBLE TAPER AND VOLUME MODEL FOR LOBLOLLY PINE. B. R. Zutter*, and D. M. Hyink*. Dept. of Forestry, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

A tree taper and volume model for loblolly pine is presented in which cubic-foot volume over a particular stem length is coincident with an integrated function of stem taper over that length. This compatible taper and volume model possesses desirable mathematical and geometric properties consistent with established mensurational formulae. Derived from two independently developed volume ratio models, the integrated volume equation takes the form of the classical Schumacher (aD^{bH}) tree volume equation. The model may be of particular advantage in applications involving multiple product yield estimation since the dimensional attributes of specific products are independent of the model and may be completely specified by the user.

Astronomy, Mathematics, and Physics

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

DEEP INELASTIC ELECTRON SCATTERING FROM ⁵⁶Fe. R. Altemus*, D. Day*, J. S. McCarthy*, R. R. Whitney*, J. Wise*. Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901.

Deep inelastic electron scattering spectra were obtained at the MIT-Bates Linear Accelerator at 160° 140° and 90° in the energy range of 100 MeV to 370 MeV to 370 MeV. Transverse and longitudinal response functions, in the region of the quasi elastic peak, for vector momentum transfers of 410 MeV/c will be presented. Comparisons with a Fermi gas are included.

HOLE MODEL FOR THE CUPRIC SITE IN BLUE PROTEINS. A. Aqualino* and A. S. Brill*, Dept. of Physics, Univ. of Virginia, Charlottesville, VA 22901.

A quantum mechanical model that accounts for the unusual spectroscopic properties of the cupric site in the blue protein azurin has been developed. Oscillator strengths and rotational strengths simulated by adjusting the six hybridization parameters of the eight level united atom model are in good agreement with the values determined by analysis of the experimental optical absorbance and circular dichroism (CD) spectra. Adjustment of these parameters fixes the geometry of the binding site. Upon inclusion of orbital reduction factors (ORF), which make explicit the extended radial nature of atomic orbital wavefunctions in a united atom approach, these same parameter values reproduce the principal values of the g and A tensors characterizing the experimental electron paramagnetic resonance (EPR) spectrum. The three ORF, one for each principal direction, indicate the rhombicity in g values is due to extensive differences in hole delocalization.

DYNAMIC SPECTRAL ANALYSIS OF A SYNTHESIZED DOUBLE-REED INSTRUMENT. L. Neel Beard, Dept. of Physics, Hampden-Sydney College, Hampden-Sydney, Va. 23943

The upper register double-reed voice of a breath-controlled electronic musical instrument has been analyzed. The results of the analysis are presented in terms of amplitude envelopes (amplitude vs. time plots) for each of the first eight harmonics. Several notes have been analyzed.

Two parallel techniques were used in the analysis:

a) the waveforms were analyzed directly using a General Radio Wave Analyzer; b) the waveforms were digitized with the aid of a microcomputer interfaced to a PDP-11 mini-computer, with subsequent Fourier analysis.

Each analysis corresponds to a particular value of time in the evolution of the note. In ordinary use, a voltage derived from pressure exerted by the breath alters the amplitude and timbre of the note. For analytic purposes, fixed voltages are substituted for this dynamically changing voltage. This permits a series of static analyses of the dynamic process.

Much of the work required in this investigation was performed by a group of non-science majors enrolled in a Physics of Music course.

The results will be compared with published data corresponding to the actual oboe.

DEEP INELASTIC ELECTRON SCATTERING FROM NUCLEI.

H. Bidasaria, P. Fishbane, and J. Noble. Physics Dept., University of Virginia.

We fit observed inelastic e-He³ cross-sections in terms of known e-nucleon cross-sections using the impulse approximation. Agreement is good except on either side of the quasi-elastic peak.

LASER-INDUCED DIELECTRIC BREAKDOWN IN UF_6 . E. B. Boysen*, S. S. Fisher, and S. W. Allison*, School of Engr. and Appl. Sci., U. Va., Charlottesville, Va. 22901.

Several characteristics of dielectric breakdown in UF_6 induced by focusing a high-power, pulsed nitrogen laser in the gas are described. The principal observable phenomenon is emission of photons from the breakdown zone (from the "spark"). This emission is characterized with respect to its spectrum, its dependence on laser power and gas pressure, and several other parameters. A second observable process is the yield of ions. This yield is studied by collecting ions as a function of the collecting electric-field strength, and by delaying the time, following the laser pulse, before this field is switched on. The process is also characterized by collecting the resulting precipitate and analyzing it microscopically and chemically.

LABORATORY DEVELOPMENT OF A HIGH Q CLOCK. W. Stephen Cheung* and Rogers C. Ritter*, Dept. of Physics, University of Virginia, Charlottesville, Va. 22901.

A rotating rigid body in space devoid of all physical disturbances is an ideal time keeping device ($Q \sim \infty$). Realization of such a system in the laboratory is one of the several experiments with intended cosmological significance being pursued at the University of Virginia. Two tandem magnetically suspended rotors corotate axially with the upper rotor protecting and following the lower one at the same angular speed by appropriate feedback. Such a mechanism together with low gas pressure, active and passive shielding will allow the lower rotor to become a minimally disturbed macroscopic time keeper. A simple magnetic suspension will be demonstrated, the status of such development will be reported, and applications will be discussed. NSF Grant PHY78-03208 and NBS Grant G8-9025.

THE SPUTTERING OF ICE BY FAST IONS. R. S. Evatt* and R. E. Johnson, Dept. of Nuclear Engineer. and Engineer. Physics, Univ. of Va., Charlottesville, Va. 22901. W. L. Brown, W. M. Augustyniak*, and L. J. Lanzerotti*, Bell Laboratories, Murray Hill, NJ 07974.

The sputtering of H_2O ice has been measured for hydrogen, helium, and carbon ions between 6 keV and 1.8 MeV. The erosion coefficient, S , is much too large to be explained by the normal (collision-cascade) theory of sputtering due to the nuclear energy loss, $(dE/dx)_n$, and is related to the electronic energy loss, $(dE/dx)_e$. S is proportional to $(dE/dx)_e$ for hydrogen and helium ions in the energy range examined, consistent with a coulomb repulsion model of the erosion mechanism. At temperatures greater than 100 K, a thermally activated erosion process is observed, which is associated with defect formation and migration in the ice.

TECHNIQUES FOR MEASURING MAGNETIC ANISOTROPY IN MATERIALS AND FOR OBSERVING OPTICALLY INDUCED TRIPLET STATES IN AROMATIC MOLECULES USING A SUPERCONDUCTING SUSCEPTOMETER. T. L. Ferris, B. S. Deaver, Jr. and T. J. Bucelot*, Dept. of Physics, Univ. of Virginia, Charlottesville, Va. 22901 and C. J. O'Connor* and E. Sinn*, Dept. of Chemistry, Univ. of Virginia, Charlottesville, Va. 22901.

The SQUID superconducting susceptometer's combination of speed and sensitivity allows the development of new methods for measuring the magnetic properties of materials. Techniques have been developed for measuring magnetic anisotropy and observing the excited state of an aromatic molecule which also illustrate the system's versatility. In order to measure anisotropy, the susceptometer employs two pairs of pick-up coils. These are arranged so that the magnetization of a sample can be measured in two perpendicular directions simultaneously. By appropriate rotation of the sample, the magnetization in a direction perpendicular to the original two can be found. In the second technique, an ultraviolet laser is used to excite aromatic molecules into a triplet state. The susceptometer measures the subsequent magnetic decay as a function of time, temperature, and magnetic field, and from this can be found the lifetime, quantum yield, and absolute magnetic moment of the state. (Research supported by NSF grant DMR78-25791.)

A NEW SOFT X-RAY DETECTOR. C. Franck,*F. Zutavern,* E. Käline,*T. Aton,*and S. Schnatterly,* Physics Department, University of Virginia, Charlottesville, Va. 22901.

We have devised and successfully tested a position-sensitive detector for soft x-rays and vacuum ultraviolet light. Our device consists of a commercial photodiode array with element spacing equal to 25 μm , coated with a high efficiency phosphor, $Y_2O_3:Eu$. The phosphor is held on the photodiode surface with a thin layer of blue (water glass: sodium silicate). Measurements at 78, 89, 95 and 108 eV reveal that the detector yields about 4 electrons per photon at 100 eV. The detector response increases linearly with energy in this range.

COUNTING CHAINS OF SETS. H. W. Gould, Dept. of Math., West Virginia Univ., Morgantown, W. Va. 26506

We enumerate chains $X_1 \subset X_2 \subset \dots \subset X_m \subset X_{m+1}$ of $m+1$ subsets (m links) connecting two subsets in the lattice of all subsets of a finite set X of n elements. For brevity we write ABCD for A, B, C, D and use a dash (-) in place of the set inclusion sign (\subset). A chain is maximal if $|X_{i+1}| = |X_i| + 1$ for all $i, 1 \leq i \leq m+1$. Thus $\emptyset-A-AB-ABC-ABCD$ is maximal, $\emptyset-AB-ABCD$ is not. The chains (labelled) $A-AB-ABC, B-AC-ABC, A-AC-ABC, C-AC-ABC, B-BC-ABC, C-BC-ABC$ may be exemplified by one chain (unlabelled), $A-AB-ABC$, of the same type. We show that the number of unlabelled chains with k links is $U(n, k) = \binom{n}{k+1}$. The number of labelled chains with k links is $C(n, k) = \sum_{0 \leq j \leq k} (-1)^{k-j} \binom{k}{j} (j+2)^n$. The number of labelled chains with k links but omitting the use of \emptyset as a bottom element in any chain is given by $D(n, k) = (k+1)S(n+1, k+2)$ where $S(n, k)$ is Stirling's number of the second kind (Riordan's notation). Special case: The number of maximal labelled chains from \emptyset to X itself is just $C(n, n) = n!$. Tables of the numbers $U(n, k)$, $C(n, k)$, and $D(n, k)$ are given for $0 \leq k \leq n$, $0 \leq n \leq 7$. Many other enumeration questions arise, e.g. how many chains link an r -element set to an s -element set? Same query: if we require the chain to be maximal, or labelled, or unlabelled, or some combination of such conditions.

RESONANCES IN ATOM-SURFACE SCATTERING. M. Haller*, J. Hutchison*, N. R. Hill*, and V. Celli*, Department of Physics, University of Virginia, Charlottesville, VA 22901.

The scattering of light atoms from the surface of a crystal provides an effective probe of the surface geometry and the atom-surface interaction. The analysis of the scattering intensities when the incident atom resonantly skips along the crystal surface gives especially good detail of this interaction. We present theoretical methods used to interpret recent experimental measurements in this area.

COMPARISON OF EXECUTION TIMES FOR ITERATIVE AND RECURSIVE PROCEDURES ON THE HEWLETT-PACKARD 3000 COMPUTER. Preliminary report. Roger A. Haun* and Diane M. Spreser, Dept. of Mathematics and Computer Science, James Madison Univ., Harrisonburg, VA 22807

The use of recursive procedures in computer programs is controversial, even in those programming languages (such as ALGOL or PASCAL) where recursive calls are a feature inherent to the language. Recursive processes have the advantage that they may be coded in a clear and compact manner. At the same time, they often execute inefficiently because of the overhead associated with maintaining the recursion, and because it is easy to overlook redundant operations.¹

One might suspect, however, that the overhead associated with recursive procedures would be relatively insignificant on a stack-oriented machine, such as the HP 3000. We use empirical means to compare the execution times required for iterative and recursive procedures. We conclude that significant overhead is associated with recursive procedures, even in stack-oriented machines.

¹J. L. Pfaltz, *Computer Data Structures*, McGraw-Hill, New York, 1977, p. 129.

A NIOBIUM SUPERCONDUCTING DETECTOR OF Sub-keV ATOMS. M.F. Henshaw and J.W. Boring*. Dept. of Nuclear Engineering and Engineering Physics, Univ. of Va., Charlottesville, Va. 22903

A low energy particle detector has been constructed using a long, narrow niobium microbridge. The microbridges were typically $50 \times 2 \text{ Å}$ in size and have been made as thin as 75 Å using both R.F. sputtered films and D.C. sputtered films. A series of I-V characteristic curves have been made at different temperatures and four distinct temperature regimes were noticed and characterized. There is a temperature range in which a normal region due to a thermal hot spot is stable; above this temperature range, the normal region collapses, and below it, the normal region grows.

Operating the detector in the temperature range in which the normal region collapses and current biasing near the critical current for this temperature, the device was able to consistently detect argon ions with energies from 200 eV to 1 keV. The detector efficiency is near 100 percent if the sensitive region of the bridge is used. The pulse heights and widths were independent of the particle energies, from which it is concluded that the pulses were an intrinsic fluctuation phenomena of the material used.

GAS-DENSITY MEASUREMENTS IN UF_6 FREE JETS BY THE RAYLEIGH-SCATTERING METHOD. P. A. Housington* and S. S. Fisher, School of Engr. and Appl. Sci., U. Va., Charlottesville, VA 22901.

Gas density distributions in free-jet expansions of UF_6 from converging nozzles into a vacuum chamber are determined by measuring the Rayleigh scattering of laser photons by the gas. For these measurements, a 2W continuous-wave argon-ion laser is focused in the jet at the point of interest and light scattered perpendicular to both the axis and the polarization direction of the laser beam is monitored with a photomultiplier tube. The resolved scattering volume is 0.1 mm in diameter by 1.0 mm long. A photon-counting network is used to measure the scattered light. The smallest density resolved is equivalent to that for UF_6 at 0.003 torr and 300 K. The most accurate measurements have 1% uncertainties of order 2%. Measured densities are in good agreement with theoretical predictions.

AN ANALYTIC APPROACH TO BOUND-STATE SCATTERING PROBLEMS: THE SCHRÖDINGER EQUATION IN ONE DIMENSION. Edward A. Johnson* & H. Thomas Williams, Jr. Physics Department, Washington & Lee University, Lexington, VA. 24450

This paper presents an analytic approach to off-mass-shell scattering problems using the one dimensional, time-dependent Schrödinger equation and elementary quantum physics techniques. Extensive computer graphics assist in the physical interpretation of calculated results.

A rectangular potential barrier centered in an infinite square well models the potential of interest. Investigation of allowable energies as a function of barrier width shows that energy levels occur in odd-even pairs with a predictable spacing between odd and even levels that narrows as the barrier widens. Computer plots illustrate the behavior of the function and provide an explanation for experimental observations.

Fourier techniques are used to form a Gaussian shaped wave packet from individual wave functions. As it sloshes from side to side in the well, the probability density function, $\Psi\Psi^*$, scatters off the barrier. Computer generated snapshots depict a bound-state scattering event in probability space and illustrate the time evolution of $\Psi\Psi^*$.

THE DEVELOPMENT OF AN OPTICAL SYSTEM USING A SPLIT PHOTODIODE FOR MAGNETICALLY SUSPENDING A PRECISION ROTOR. G. Jones* and R. Ritter*. Physics Department, University of Virginia, Charlottesville, Va. 22901.

For possible gravitational experiments interest lies in the development of a magnetically suspended precision rotor with Q values of at least 10^{13} to 10^{14} . Since the rotational frequencies of this system will typically be less than 2 Hz, an extremely high decay time and hence a stable nearly frictionless magnetic bearing is required. The magnetic suspension tested uses a split photodiode whose output is fed into a differential circuit. It is known that such a system results in greater thermal stability as well as other improvements to the magnetic bearing. Some studies of rotor dynamics at high vacuum will be presented. NSF Grant PHY78-03208 and NBS Grant GB-9025.

g₂-FACTOR MEASUREMENT IN SULFUR NEGATIVE IONS. R.M. Jopson* and D.J. Larson*, Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901.

Precision measurements of the internal structure of negative ions are almost nonexistent due to the difficulty of obtaining isolated ions for a reasonable length of time. We describe a general technique for measuring the magnetic structure of negative ions and apply it to S⁻. Approximately 10⁶ ions are stored in a Penning ion trap in a magnetic field of 0.77 Tesla. 597 nm laser light is used for both preparing the states and probing the 14 GHz microwave Zeeman transition. The accuracy of the measurement is currently limited by the stability of the magnetic field. This work was supported by the Office of Naval Research.

INELASTIC ELECTRON TUNNELING SPECTROSCOPY. J.C. Lee, and R. V. Coleman, Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

Inelastic electron tunneling spectroscopy (IETS) is a sensitive technique for obtaining the vibrational spectra of molecules at the interface region of metal-insulator-metal tunnel junctions. Doping the interface regions with molecules of interest, the tunneling junctions can be used for the study of chemisorption and interactions at the interface region.

High resolution doped tunnel junctions using different combinations of aluminum, magnesium, or tin base electrode the oxidized film insulating tunnel barrier, and lead, tin, or silver counterelectrode have been fabricated and measured. Their spectra show variations due to the interactions among the adsorbed molecules, the oxides, and the counterelectrodes. There is evidence to suggest that IETS can contribute to the understanding of the phenomena of surface enhanced Raman spectroscopy.

*Supported by DOE contract DE-AC05-78ER05776

DIAMAGNETIC SHIFTS IN ATOMIC HYPERFINE STRUCTURE. S. J. Lipson*, Dept. of Physics, Harvard Univ., Cambridge, MA 02138 and D. J. Larson*, Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901.

Several methods are available for the recently measured diamagnetic shift in the dipole hyperfine structure of atomic Rubidium⁺. Shifts in the contact and spin-dipole components quadratic in applied magnetic field appear in second order perturbation theory. These have been evaluated by solving the associated inhomogeneous differential equations¹. For the hydrogenic case, and analytic solution has been found which gives the shift as a function of principal quantum number. Together with quantum defect theory, this provides a first approximation for the effect in alkali atoms.

This work was supported by the National Science Foundation.

DIFFERENTIAL CROSS SECTION FOR $^2\text{Be}(p,\pi^+)^2\text{B}$ REACTION NEAR THRESHOLD. M. Madden, D. Jenkins, O.P. Gupta, D. Long, Virginia Polytechnic Institute and State Univ., Blacksburg, VA 24061; A. Bacher, M. Pickar, Indiana Univ.; P. Debevec, Univ. of Illinois.

The angle and energy distribution of gammas for decaying π^+ 's from the (p,π^+) reaction on ^9Be have been measured at a proton kinetic energy of 144 MeV. The angle and energy of each gamma was measured with a lead glass, multiwire-proportional-chamber telescope. With only s and p-waves, $d\sigma/d\Omega$ may be expressed as:

$$d\sigma/d\Omega = A + B\cos\theta + C\cos^2\theta$$

where θ = c.m. angle of π^+ and A,B,C are parameters. The cross section can be transformed into an angular distribution for the coincidence photons:

$$N = K(A + B\tau_1 + C\tau_2)$$

where K, τ_1, τ_2 are functions of the measured angles. The data (226 points) was subjected to a maximum likelihood fit which yielded the following preliminary values for the parameters A, B and C respectively: 0.978, -0.505 ± 0.176 , 0.065 ± 0.045 .

1) N. P. Economou, S. J. Lipson, and D. J. Larson, Phys. Rev. Lett. **38**, 1394 (1977).

2) R. M. Sternheimer, Phys. Rev. **146**, 140 (1966).

ULTRA-HIGH RESOLUTION IR SPECTROSCOPIC ANALYSIS OF OZONE NEAR 1129 CM⁻¹. L.N. Majumara*, G.E. Copeland, C.N. Harward, Dept. of Physics, Old Dominion Univ., Norfolk, Va. 23508

The analysis of high resolution infrared spectra serves as an important basis for identification and measurement of concentration profiles of various atmospheric "pollutant" molecules through remote sensing techniques. The absorption coefficient and collision broadening parameters of a selected O₃ transition has been measured for pressures up to 10 torr. This was accomplished in a Beer's law experiment utilizing a current-tuned Pb_{1-x}SnSe diode laser as a radiation source. Computerized data collection and analysis has led to the development of unique interactive software which is useful in a general way for spectroscopy of this type.

(Partially supported by NASA-LaRC-Grant NSG 1466)

METHODOLOGY FOR MULTIELEMENT NEUTRON ACTIVATION ANALYSIS OF TRACE AND MINOR ELEMENTS IN XYLEM TISSUE. P. W. Marshall* and John R. Gordon, Dept. of Physics, James Madison Univ., Harrisonburg, VA. 22807

A methodology has been developed for determination of concentrations of trace and minor elements in tree-ring xylem tissue using instrumental neutron activation analysis. Absolute multielement calculations have been made using photopeak integrals from the gamma-ray spectra of the activated samples, measured counting efficiencies, and a data file of nuclear properties. The accuracy of the procedure was tested using two standard reference materials.

Both angular and radial variations in the elemental composition of tree-ring xylem representing two locations have been determined for the following eleven elements: Na, K, Ca, Mn, Fe, Co, Zn, Br, Rb, La, and W. The results showed angular changes that ranged from 100 to 300 percent of the average value for a given element. The changes in the elemental concentrations which were found radially along a growth increment corresponding to a 100 year time interval were analyzed as ratios relative to sodium. Those elements involved in active transport during the growth cycle exhibited expected changes from sapwood to hardwood; while evidence of long range changes in environmental conditions at the sample site were observed for a limited number of elements.

These results were not surprising in view of the previous findings of more limited studies.

AN INTERPRETATION OF QUANTUM MECHANICAL MEASUREMENT. M. T. Milbocker*, Dept. of Physics, Kempsville High School, Virginia Beach, Virginia 23462

The author has outlined several of the more important interpretations of measurement in quantum mechanics and discussed the problems arising from them. Particular attention was paid to the work of Bohr, Heisenberg, and von Neumann and a tentative proposal was made for a possible interpretation which would mitigate some of the problems and dilemmas. This interpretation was essentially that proposed by Margenau in terms of latent variables. He defines measurement to be any operation with physical apparatus which results in a number. Further he makes the distinction between the preparation of a state and the measurement of the state. A preparation puts the quantum system into a particular state whereas the measurement frequently destroys the state in question. This paper presents several criteria to help in the evaluation of the alternatives presented and carries further the suggested interpretation mentioned by Margenau.

NEW WRINKLES ON OLD DEMONSTRATIONS. R.B. Minnix and D.R. Carpenter, Jr. Physics Dept. Va. Military Inst., Lexington, VA 24450.

Old demonstrations viewed by a new observer for the first time often trigger fresh ideas on how to make a physical principle come alive for students. In short courses on physics demonstrations given since 1973 at VMI, participants have left behind a rich legacy for future use.

Bernoulli's Principle can be shown in the curving of styrofoam balls, of toilet paper rolls and styrofoam cups propelled forward and spinning with rubber bands wrapped around them. An indoor tornado can be formed by inverting a round gallon jug filled with water to which a swirling motion has been imparted.

The notes of both a closed and an open tube, one octave apart, can be sounded by patting the end of the tube with a flattened palm. Square waves can be synthesized using a violin bow to excite a taut wire. The pattern is made visible on an oscilloscope using the voltage generated in the wire as it moves between the poles of a strong magnet placed at the wire's mid-point.

The principle of a measurement being disturbed by the measuring instrument can be illustrated using a meter stick to measure a column of water in which it is immersed.

PION ABSORPTION IN THE HELIUM ISOTOPES. L. Orphanos*, R. Altemus*, P. Gugelot*, J. Källne*, J. McCarthy*, R. Minehart*, Dept. of Physics, Univ. of Virginia, Charlottesville, VA 22901. P. Gran*, B. Holstad*, C. Morris*, E. Wadlinger*, Los Alamos Scientific Lab, Los Alamos, NM 87544. C. Perdrisat*, Dept. of Physics, College of William and Mary, Williamsburg, VA 23185.

We have measured the differential cross-section of $3,^4\text{He}(\pi^+n)^2,^3\text{H}$ above the (3,3) resonance using the P^3 pion channel at LAMPF. The reaction was measured for pion kinetic energies $T_\pi = 285\text{--}575$ MeV, using the recoil detection technique to measure TOF, ΔE , and E of $^3,^4\text{H}$. Angular distributions $\frac{d\sigma}{d\Omega}(\theta, T_\pi)$ will be presented and interpreted within the framework of various models.

NEUTRON FLUX DISTRIBUTION FROM A TOROIDAL PLASMA SOURCE. W. G. Pettus, Babcock & Wilcox Co., Lynchburg Research Center, Lynchburg, Va. 24505

The first fusion power reactors will most likely be of the tokamak type and will employ the deuterium-tritium reaction. The tokamak is a magnetic plasma confinement device in which the reactor vessel is of toroidal shape. Most of the energy released in the D-T reaction is carried by high energy neutrons which pass through the vessel wall and are absorbed in a surrounding blanket region.

Because of the toroidal distribution of the source, the neutron distribution at the wall is, in general, non-uniform. This variation can have important consequences in terms of blanket reaction rates and radiation damage to the wall. In principle, a measurement of the flux distribution at the wall can also be used to infer the distribution of the fusion reactions and to identify certain plasma parameters.

This paper presents a convenient analytical formulation of this flux distribution and discusses possible applications with respect to radiation damage and plasma diagnostics.

PRIMARY ELECTRON PEAKS IN ELECTRON ENERGY DISTRIBUTIONS IN MULTIDIPOLE ARGON PLASMAS. J. W. Sealock* and G. R. Taylor, Physics Department, James Madison University, Harrisonburg, Va. 22807

The presence of primary electrons as a second species in the electron energy distribution in argon plasmas is observed by operating a multidipole plasma device at low neutral pressures in an unconventional manner. The mean energy of the primary electron distribution is shown to vary linearly with the effective plasma discharge voltage. The change in the plasma potential with the effective discharge voltage is shown for constant secondary electron current. The plasma characteristics are determined from electrostatic probe characteristics using a modified Pruvvesteyn method.

A DOUBLE CRYSTAL MONOCHROMATOR FOR SYNCHROTRON RADIATION. D.J. Scherer and W.C. Sauder, Dept. of Physics, Va. Military Inst., Lexington, VA 24450, and W.P. Trower, Dept. of Physics, VPI&SU, Blacksburg, VA 24061.

We present a design for a monochromator for use with synchrotron sources based upon the principles of the monolithic double crystal spectrometer. The output beam is diffracted into a segment from 30° to 150° from the forward beam direction as the instrument is set for detailed scanning in regions from 2.8 \AA down to 0.6 \AA . High dispersion scanning takes place in a plane perpendicular to the synchrotron orbit. The instrument is characterized by very high resolution and the elimination of higher orders.

¹William C. Sauder, James R. Huddle, J.D. Wilson, and Robert E. Lavilla, Phys. Lett. 63A, 313 (1977).

ANALYSIS OF SUPERCONDUCTING WEAK LINKS USING A COMPUTER MODEL. J. L. Spencer*, and B. S. Deaver, Jr. Dept. of Physics, Univ. of Virginia, Charlottesville, VA 22901.

A simple phenomenological model of a superconducting weak link has been implemented on a computer. The shape of V-I curves generated by the model is shown for a wide range of pair relaxation times. The curves closely match experimental data exhibiting hysteresis when long relaxation times are used, as well as non-hysteretic data at short relaxation times. Time and phase relations for instantaneous voltage and for pair density are explored to find the origin of hysteresis. (Research supported by NSF grant DMR78-25791.)

MUON SPIN ROTATION STUDIES OF IRON DILUTED WITH SMALL AMOUNTS OF TRANSITION METALS. C. E. Stronach, Va. State Univ., Petersburg, Va. 23803; B. D. Patterson*¹ and A. S. Arrott*, Simon Fraser Univ., Burnaby, B. C., Canada; A. T. Flory*, Bell Laboratories, Murray Hill, NJ 07974; W. J. Kossler*, Col. of William & Mary, Williamsburg, Va. 23186; W. F. Lankford, George Mason Univ., Fairfax, Va. 22030

Positive muons from the TRIUMF cyclotron were implanted in samples of Fe alloyed with small (typically 2-4%) concentrations of impurity elements. Temperatures ranged from near room temperature to about 630K for Fe(Mo) and Fe(Nb), and to 525K for Fe(Ti). The contact hyperfine fields were determined by subtracting the Lorentz fields from the B_0 obtained from the precession frequencies, and were compared with those observed in pure Fe. The low-temperature behavior suggests that the Mo, Nb, and Ti impurity sites are attractive to the μ^+ , and the high-temperature behavior suggests that the Mo decreases the magnitude of the hyperfine field less than that expected for pure dilution, Nb approximates pure dilution, and Ti reduces its magnitude more than expected from pure dilution. (Supported by NASA, NSF, National Research Council of Canada, and the Commonwealth of Virginia)

*Present address: Univ. of Zurich, Switzerland.

EFFECTS OF POLARIZATION ON π^0 SCATTERING. M. C. Sullivan and D. A. Jenkins, Virginia Polytechnic Institute and State Univ., Blacksburg, VA 24061

Measurements of the π^0 differential cross section near threshold of (p,π^0) reactions have been made using an unpolarized proton beam. This is done by measuring the γ distribution produced by $\pi^0 \rightarrow \gamma\gamma$ and assuming only s and p waves in the π^0 angular distribution. It is now useful to investigate the effects of using a polarized beam on the γ distribution measured in the experiment. The π^0 cross section equation has been analyzed with the result that certain areas in the γ distribution are sensitive to beam polarization. For example, if γ are counted at 90° and -90° from the beam with azimuthal angles of 240° and 90° the differential cross section varies with beam polarization.

DATA ACQUISITION THROUGH RTMULTI WITH A SINGLE-DATA TRANSFER CONTROLLER. R. Vaughan and D. Jenkins, Physics Department, Virginia Polytechnic Institute and State Univ., Blacksburg, VA. 24061.

RTMULTI is a data acquisition system developed at Fermi Lab for a Jorway 411 DMA controller.¹ The system has a data acquisition component and a component called MULTI for data analysis and control. We have incorporated a data analysis section which uses a EGand DCO11 crate controller on both a PDP11/34 and PDP11/40 computer. The system uses components which are commercially available.

1. RT/RXS MULTI: Packages for Data Acquisition and Analysis in High-Energy Physics, Bartlett, Biel, Curtis, Dosen, T. Lagerlund, Ritchie and Taff, Submitted to Topical Conference on Computerized Data Acquisition Systems in Particle and Nuclear Physics, 1979.

Biology

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

PASSAGE OF HOST ANTIBODY ACROSS THE DIGESTIVE TRACT OF THE AMERICAN DOG TICK, DERMACENTOR VARIABILIS, Steven Ackerman, F. Brian Clare, T. W. McGill, and Daniel E. Sonenshine, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, VA 23508.

The ability of host macromolecules to pass across the digestive tract into hemolymph of female ticks was investigated. Electrophoretic and immunologic analyses detected various serum constituents in hemolymph following infestation on rats or rabbits or following artificial feeding of whole serum or purified serum substances. The effects of digestion and/or transport of these macromolecules on protein structure and antigenicity was examined. Furthermore, host antibodies were detected on salivary glands or ovaries dissected from ticks infesting rabbits immunized with extracts of these organs. No antibodies were detectable on 1) organs from ticks infesting a non-immunized rabbit, 2) salivary glands from ticks infesting a rabbit immunized with ovary extracts, or 3) ovaries from ticks infesting a rabbit immunized with salivary gland extracts. The implications of this ability of antibodies directed against internal organ antigens to pass across the ticks digestive system, while retaining specific antibody activity, will be discussed with regards to the development of an anti-tick vaccine.

ENZYME-LINKED IMMUNOSORBENT ASSAY (ELISA) FOR THE DETECTION OF ANTIBODIES TO HUMAN SPERM. Steven Ackerman, William Garrison, J.W.E. Wortham, R. James Swanson, and Julian Gutierrez., Dept. of Biol. Sci., Old Dominion Univ., Norfolk, VA 23508.

Among the 60 million reproductively-active American couples, it has been estimated that approximately 15% experience infertility problems. In many cases, infertility can be correlated with antibodies to human sperm occurring in either the serum and/or cervical mucus of the female or in the serum and/or seminal plasma of the male. In the Andrology Laboratory of Old Dominion University we currently test for antisperm antibodies via immobilization and agglutination procedures. This report outlines the development of a novel assay to identify, quantitate and characterize antisperm antibodies via enzyme-linked immunosorbent assay (ELISA). Data will be presented to indicate optimal incubation parameters, antigen concentrations and methods of quantitation. Results to date indicate that the ELISA method for detection of antisperm antibodies is a relatively simple, extremely sensitive, and, in many ways, preferable assay than others currently in clinical use.

THE EFFECTS OF ESTRADIOL BENZOATE ON THE CARDIOVASCULAR SYSTEM OF THE RAT. S. M. Ashe*, T. W. Toney, and L. G. Martin. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284

The effects of estradiol benzoate on coronary blood flow in the adult female rat was studied. Female control rats, castrates, and castrates receiving estrogen were used. Tracer microsphere studies of myocardial blood flow allowed the quantitation of the effects of estrogen upon the coronary circulation. It would thus appear from data that estrogen does have the ability to modulate coronary blood flow. (Supported in part by ADA Grant 90-A-1245(02) awarded to the Virginia Center on Aging, ADA Grant 90-A-1392(01) awarded to the Dept. of Gerontology, Va. Commonwealth Univ., and Faculty-Grant-in-Aid #1-93035 awarded to Loren G. Martin, Va. Commonwealth Univ.)

SOCIAL ENVIRONMENT AND SEXUAL MATURATION IN MALE PRAIRIE DEER MICE, PEROMYSCUS MANICULATUS BAIRDI. T.E. Babb and C.R. Terman. Dept. of Biology, College of William and Mary.

Male deer mice, 21-24 days of age were placed into the following adult social situations: with 6 females, 6 males, 3 males plus 3 females, single female, single male, and isolated (control). After 14 days the young were killed and their testes and seminal vesicles weighed. The testes and seminal vesicles of young reared with any group containing adult males were significantly smaller than those of controls. The seminal vesicles of males housed with single females were significantly larger than all other treatments.

The effectiveness of urine versus physical contact on maturation was tested in a subsequent experiment. Young males 21-24 days old were placed with adult males or adult females exposed to urine of adult males or adult females, or exposed to distilled water. Urine was collected every other day and refrigerated. Three strokes of a #2 artist's paint brush, freshly dipped in urine or water were applied daily in a designated corner of the appropriate cages. Young were killed at 40 days of age. The results showed that the seminal vesicles of males in contact with adult females or exposed to the urine of adult females were significantly larger than those exposed to the other treatments. Males in contact with adult males had smaller testes and seminal vesicles than those exposed to water or in contact with females or female urine. Exposure to male urine did not significantly influence the testes or seminal vesicles size compared to water.

THE RELATIONSHIP BETWEEN LARVAL BLUEGILL SURVIVAL, PARENTAL CARE, AND FISH PREDATION. M. B. Bain*, and L. A. Helfrich*. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The effect of nest preparation and guarding on the survival of larval bluegill (*Lepomis macrochirus*) was investigated. Larval bluegill mortality was estimated for a total of 77 guarded and unguarded nests (guard artificially removed). Larval bluegill mortality due to fish predation was found to be significantly greater ($p < .001$) in unguarded nests. Juvenile bluegill (3-14 cm) dominated the fish community (91%). The dominate nest predators were juvenile bluegill 7-11 cm. Larval bluegill mortality was not correlated with the density of juvenile bluegill or the density of nest predators. Fish traps placed in unguarded nests caught significantly more fish ($p < .0004$) and a greater size-range of fish than traps placed in guarded nests. Substrate analysis indicated that nest preparation substantially increased the abundance of coarse gravel (5-32 mm) and pebbles (32-64 mm) in the nest. The interstitial space between these particles provided refuge for larval bluegill. Mortalities declined as the abundance of large particles increased ($p < .05$).

The results indicate that the nest preparation and guarding activities of the male parent increases survival of larval bluegill. Nest preparation alters substrate composition to provide concealment of larvae. Nest guarding reduces the number of actual nest predators.

A MORPHOLOGICAL INVESTIGATION OF *Xenopus laevis* DEVELOPMENT USING THE SCANNING ELECTRON MICROSCOPE. Barry L. Browder* and Carolyn M. Conway, Dept. of Biology, Va. Commonwealth Univ., Richmond, VA 23284, Ian Uydess, Philip Morris Res. and Development Ctr., Richmond, VA 23261, and A. F. Conway, Dept. of Biology, Randolph-Macon Col., Ashland, VA 23005.

A morphological study of developmental processes in *Xenopus laevis* was conducted using the scanning electron microscope. Developing specimens (first cleavage through early third form tadpoles) were dejelled, fixed, critically point dried, sputter coated with gold-palladium, and examined in a JOEL-JM/35A SEM. Morphological parameters investigated were cell shape changes, appearance of microvilli and cilia, as well as the external morphology of organ primordia and definitive structures. During cleavage (stage 8) microvilli were observed in numerous cleavage furrows of the animal pole. Microvilli were also observed in early gastrulae (stage 10) on the invaginated dorsal lip and on cells in the blastoporal groove. Ciliary tufts first appeared just before completion of neural fold fusion (stage 20). These ciliary tufts increased in number and location as development proceeded. Lateral line organs of early 3rd form tadpoles (stage 49) were observed to have cupulae extending from the center of each. The findings of this study suggest that a more extensive study of morphological changes during *X. laevis* development needs to be conducted with both scanning and transmission electron microscopes. (Supported by Philip Morris, USA, and Va. Commonwealth Univ.)

ASSOCIATION OF SEMEN FACTORS WITH THE RECOVERY OF UREA-PLASMA UREALYTICUM. Rebecca Cinton, J. W. E. Wortham and Anibal Acosta. Dept. of Biol. Sci., Old Dominion Univ., Norfolk, VA 23508.

Ureaplasma urealyticum (T-mycoplasma) has generated considerable interest to clinical investigators since its discovery in 1954 because of the high incidence of recovery from cases of nongonococcal urethritis, spontaneous abortions and female urogenital infections. *Ureaplasmas* are suspected etiologic agents of human infertility. The routine investigation of an infertile marital unit typically excludes the detection of ureaplasmas in cultures of semen and cervical mucus. The Andrology Laboratory of Old Dominion University has examined the potential effects of *Ureaplasma urealyticum* on various parameters of semen quality in the subfertile male. Differences between sperm count, ejaculate volume, sperm morphology, sperm motility and sperm viability are compared between *ureaplasma* positive and *ureaplasma* negative semen specimens.

EVALUATION OF SMALL RODENT POPULATIONS AT FOUR DISMAL SWAMP STANDS. F. E. Breidling*, F. P. Day, Jr., R. K. Rose*. Department of Biological Sciences, Old Dominion University, Norfolk, VA 23508.

Small rodent populations of four Dismal Swamp stands are currently under investigation to determine the causes of the low density and variety of small rodents, and to compare populations among the four stands. Rodents were live-trapped in May and October 1979, while flood levels were checked. Mast and other fruits are being collected. "Cafeteria" tests are under way; fruits will be analyzed as to caloric value and nutrient content. Live-trapping has yielded low numbers of *Peromyscus leucopus* and *Ochrotomys nuttalli*. Flooding appears to affect species diversity but not density. Mast availability is low, and may limit the size of rodent populations. (Supported by VAS grant).

INFLUENCES OF FOREST CONVERSION ON SONGBIRD COMMUNITIES IN THE CENTRAL PIEDMONT OF VIRGINIA. E.L. Childers*, T. L. Sharik, and C. S. Adkisson*. Dept. of Fisheries and Wildlife Sciences and Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Bird sampling transects 100 m long by 50 m wide were established in loblolly pine plantations ranging in age from 1 to 42 yrs, and in second-growth native pine-hardwood and hardwood stands. Each of several developmental stages of the pine plantations and the native forests were represented by three replicates, for a total of 39 sample stands. During late summer (July 17 - September 6) of 1979 each transect was sampled three times in 30 minute periods between 0530 and 0900 EST. Bird species density and diversity were found to be relatively high in the young pine plantations (1-10 yrs) and the more mature pine plantations (25-42 yrs). Species numbers and diversity were relatively low in the intermediate aged pine plantations (11-24 yrs) and in the native forest stands. A total of 41 bird species were observed on transects during the sampling period.

ROLE OF MATERNAL AUTOIMMUNITY IN CHROMOSOMAL NONDISJUNCTION AND NEONATAL SURVIVAL IN MICE. Carolyn M. Conway, Dept. of Biology, Va. Commonwealth Univ., Richmond, VA 23284, and A. F. Conway, Dept. of Biology, Randolph-Macon Col., Ashland, VA 23005.

Maternal autoimmune disease results in increased chromosomal nondisjunction and reduced neonatal survival in offspring of Q-1 mice. Approximately 10% of the offspring of females immunized with thyroid homogenate were aneuploid. Approximately 50% of the offspring produced by all immune stimulated females (both thyroid specific and non-specific) were chromosomal mosaics (less than 70% of cells exhibiting identical chromosome numbers). In addition neonatal survival for offspring of females immunized with thyroid homogenate was reduced as compared to neonatal survival of offspring of non-specific immune stimulated and control females. Less than 25% of the offspring of thyroid immunized females survived to 21 days post-partum. The higher percentage of mosaic offspring indicates that immune stimulation affects post-fertilization chromosomal nondisjunction to a greater extent than chromosomal nondisjunction during oogenesis, suggesting that maternal immune stimulation results in an alteration of the environment within the female reproductive tract. These results also suggest a correlation between the type and stage of the maternal immune response during embryogenesis and neonatal survival. (Supported by the Grants-In-Aid Program for Faculty of Va. Commonwealth Univ.)

DEMOGRAPHIC PATTERNS OF MICROTUS PENNSYLVANICUS POPULATIONS IN OLD FIELD COMMUNITIES. J. A. Cranford, T. L. Derting* and D. H. Pistole†, Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

A population of meadow rodents (*Microtus pennsylvanicus*) in Blacksburg, Va. was live trapped monthly from Oct. 1977 to Nov. 1979. All individuals were aged and toe clipped on initial capture, and on all captures they were weighed, measured and their reproductive condition determined. This population exhibited a typical annual cycle of increase and decline as well as a portion of a classic three year cycle. During the low subsequent to the peak species diversity increased with the addition of four new species of rodents previously uncaptured in this habitat. The *Microtus* grid was located on the optimum habitat in this area so corridors of dispersal could be studied during the periods of high population density. Movement into and through adjacent habitats was not random but followed rather predictable corridors with high levels of protective cover. Some of these corridor areas were never acceptable habitats for permanent residence but provided access to other areas which were subsequently colonized. Growth and development of individual cohorts will be reported on as well as general loss patterns within the population.

METHODS OF HYPERPLASTIC LIVER NODULE PRODUCTION IN LABORATORY RATS AND MICE. R. E. Craven* and W. P. Trower, Dept. of Physics, VPI & SU, Blacksburg, VA 24061

The study of hyperplastic liver nodules is an important area in cancer research. The rapid and uniform induction of these nodules is essential and methods for nodule induction in rats have been developed using the procedures of differential inhibition (Solt & Farber, Toronto) and differential stimulation (Schulte-Hermann, Marburg). These methods have been used in laboratory mice at VPI & SU. Using differential inhibition, C57-BL mice were exposed to the carcinogenic diet of 2-acetylaminofluorene (2-AAF) and a partial hepatectomy. Weeks after partial hepatectomy, hyperplastic nodules were not found. It was concluded that the 2-AAF had little effect on the mice, a possible indication that carcinogenic susceptibility may be due to the physiological differences between rats and mice.

Recently at VPI & SU, differential stimulation was attempted in BALB/c and C3H mice using a single DEN inoculation and successive α -hexachlorocyclohexane (α -HCH) intubations. Null results were obtained due to an overdose of α -HCH. Currently this method is being attempted in Fischer-344 rats. (Supported in part by the ACS).

THE FATE OF AEROSOL LEAD IN TERRESTRIAL FOOD CHAINS. Robert W. Elias, Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Virginia, 24061

Atmospheric lead enters terrestrial food chains by dry and wet deposition. Dry deposition of aerosol particles occurs on plant and animal surfaces where it enters the food chain directly through food acquisition, grooming, and inhalation, or indirectly through transfer to the soil by rain washoff.

Lead from wet deposition (rain or snow) or from washoff of dry deposits from plant surfaces is largely retained by the organic fraction of the soil. Some of this lead is transferred to soil moisture where it is taken up and stored in the internal tissues of plants. A small portion of the soil lead leaves the ecosystem as surface runoff.

Data are presented which show that atmospheric inputs of dry deposition in a subalpine ecosystem are 40-60% of the total input to the ecosystem, that more than 50% of the lead which enters the food chain directly is from surface deposition, and that less than 1% of the incoming atmospheric lead is removed from the ecosystem by surface runoff. Preliminary data are used to estimate the transfer of lead from vegetation surfaces to the soil and from the soil to soil moisture.

VEGETATIONAL CHANGES ASSOCIATED WITH FOREST CONVERSION IN THE CENTRAL PIEMONT OF VIRGINIA. A. C. Felix, III*, T. L. Sharik, and B.S. McGinnis*, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst., Blacksburg, VA 24061.

Vegetation composition and structure were quantified in 21 converted stands on the Buckingham-Appomattox and Cumberland State Forests; 3 replications of 7 seral stages varying from 1-22 yrs. were selected. In converted stands, succession was greatly accelerated due to a large seed pool and rapid canopy closure from co-developing loblolly pine and cypress hardwoods. The process was exemplified by comparing changes in species variety, evenness, and vegetative coverage within the ground stratum (<1m). Variety and vegetative coverage showed the same trend: high values in stands 1-5 yrs. of age followed by a continual decline from 5-15 yrs., at which point canopy closure is complete and these variables are relatively constant for the next 7 yrs. Evenness over time was fairly constant, except for 3 yr. old stands where a decline occurred owing to extensive coverages by *Andropogon virginicus* and to a lesser extent, *Rubus* and *Rhus* spp. The Shannon-Wiener index, an integrator of variety and evenness, was more indicative of varietal changes because of the constancy of the evenness component. (Aided by NWF Fellowship)

PHYSIOLOGICAL EFFECTS OF XYLAZINE HYDROCHLORIDE (ROMPUN) APPLICATIONS IN TWO SPECIES OF MICE. David F. Gibson, Susan M. Muth and Patrick F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ. Blacksburg, VA 24061

Female *Mus musculus* (ICR Strain) and laboratory-raised male white-footed mice (*Peromyscus leucopus*) were injected (i.p.) with a 1% solution of the immobilizing drug xylazine hydrochloride (Rompun) at rates of 20 to 160 mg/kg B.W. The median lethal dose (LD_{50}) for *Mus* was between 70 and 80 mg/kg B.W. Using 4 Mus per treatment, a significant ($P<0.001$) difference was observed among dose rates with regard to induction and sleeping times which were both dose-dependent. However, this was not reproduced in a replication using 10 *Mus* per treatment. Packed cell volume (PCV), total plasma proteins (TPP) and total plasma corticosteroids varied significantly ($P<0.001$) with dose rate of Rompun in *Mus* but directions of changes were not dose dependent. PCV in *Peromyscus* did not vary with Rompun dose. TPP changes were inconsistent and corticoids were not significantly different among dose rates of Rompun. However variability in corticoid concentrations was high. Plasma glucose concentrations were significantly ($P<0.001$) different among different xylazine dosages with the response being dose dependent. Both species appear to be unsuitable models for testing on Rompun effects on blood characteristics.

EFFECTS OF XYLAZINE HYDROCHLORIDE (ROMPUN) ON RESPIRATION RATES AND RECTAL TEMPERATURES OF WHITE-TAILED DEER. David F. Gibson*, P. F. Scanlon and R. L. Kirkpatrick. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Forty-five attempts to immobilize female white-tailed deer, *Odocoileus virginianus*, (Age 5-6 y. o.) were made using a 10% solution of xylazine hydrochloride (Rompun). Respiration rates and rectal temperatures were measured at immobilization, and at 15, 30 and 90 minutes after immobilization. Respiration rates were irregular during recumbency but remained low throughout. Deer characteristically exhibited intermittent periods of apnea and hyperpnea within the 30 minutes after injection. Deep/slow and rapid/shallow respiration rates were noted in many deer. Rectal temperatures declined throughout immobilization. Mean temperatures were 39.40 \pm 0.1C, 39.30 \pm 0.1C, 38.90 \pm 0.1C and 38.10 \pm 0.2C; (\pm S.E.), respectively, for each of the observation times. In one male white-tailed deer (age 2.5 y.o.) a rectal temperature drop of 4.8C was recorded 8 hours subsequent to xylazine injection.

DOSE RATES OF XYLAZINE HYDROCHLORIDE (ROMPUN) FOR THE IMMOBILIZATION OF WHITE-TAILED DEER. David F. Gibson*, Patrick F. Scanlon, Robert J. Warren*, Anne Oelschlaeger*, and Roy L. Kirkpatrick. Dept. Fisheries and Wildlife Sci. Va. Polytechnic Inst. and State Univ. Blacksburg, VA 24061.

Adult white-tailed deer (*Odocoileus virginianus*) were immobilized with the drug xylazine hydrochloride (Rompun). In 86 instances female deer (age 5-6 y.o.) ranging in weight from 41.0 to 83.5 kg were injected with 10% xylazine at different dose rates; 73% were effectively immobilized. A total of 108 attempts to immobilize male deer (age 2-3 y.o.) ranging in weight from 51.0 to 96.0 kg was performed with 94.4% considered effectively immobilized. Effective immobilization was determined to be the period of 90 minutes over which deer could be bled by venipuncture. Dose rates of xylazine for female deer ranged from 0.74 to 3.82 mg/kg B.W. and for males, 1.60-3.37 mg/kg B.W. Despite different dose rates, mean induction times were similar between males (10.5 min±0.8 S.E., N=104) and females (10.8 min±0.8 S.E., N=76). The common xylazine concentration used was 10%, however, 5% and 1% were also effective in immobilizing deer. It is suggested that a dose rate of approximately 1.0 mg/kg B.W. (10% xylazine is suitable for periods of short immobilization in white-tailed deer, e.g. single bleedings, antler removal or hoof trimming. For longer periods of immobilization, e.g. serial bleedings, minor surgery etc., a dose rate 1.0 mg/kg is suitable.

RATE OF PASSAGE OF FOOD AND DAILY PERIODS OF MAXIMUM AND MINIMUM FOOD CONSUMPTION BY CAPTIVE RUFFED GROUSE. G. D. Harris*, G. W. Norman*, and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ., Blacksburg, VA. 24061.

Food consumption by seven pairs of captive ruffed grouse (*Bonasa umbellus*) was monitored at two hour intervals over a three day period to establish periods of maximum and minimum food consumption. The amount consumed was determined by removing the individual feed bowls at two hour intervals and weighing the contents. The grouse were fed a diet of commercial game bird feed. The period of average maximum food consumption was determined to be 3 p.m. till 5 p.m. when the grouse consumed approximately 25% of their total daily consumption. The period of average minimum food consumption was determined to be 7 a.m. till 9 a.m. when the grouse consumed approximately 8% of their total daily consumption. Three grouse were force-fed capsules of ferric oxide dye in the evening prior to roosting and three more grouse were force-fed identical capsules the next morning to determine the rate of passage. The feces of all six grouse were monitored for traces of the dye over the next two days. The grouse which had ingested the dye in the evening took approximately 43 hours on the average to completely pass the dye while the grouse which had ingested the dye in the morning took an average of only 30 hours to completely pass the dye.

THE EFFECT OF A DIETARY MANGANESE SULFATE SUPPLEMENT ON AFLATOXINOSIS IN THE MOLD GROWN HAMSTER (*Mesocricetus auratus*). C. E. Hastings, Jr. and G. C. Llewellyn. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284.

Aflatoxin is a highly potent hepatotoxic and hepatocarcinogen in many animals including the hamster. This study evaluated the effect of manganese on the precancerous changes associated with aflatoxinosis. Thirty-two male, weanling hamsters were divided into four groups, each with eight animals. The groups were differentiated according to their diet as follows: (1) Control diet - Purina Laboratory Chow #5001, (2) control diet plus 1149 ppm manganese, (3) Control diet plus 37.32 ppm total mixed aflatoxin for six weeks, followed by 13.44 ppm aflatoxin for the next two weeks, and 29.99 ppm aflatoxin for the final two weeks of the experiment and, (4) control diet plus both the aflatoxin and manganese supplements. All animals were sacrificed at the end of ten weeks. The expected depressed weight gain due to aflatoxin was potentiated by the manganese addition. Bile duct cell proliferation, enlarged nuclei, and nuclear inclusions caused by the aflatoxin were reduced by the manganese supplement. Aflatoxin was shown to cause increased liver glycogen levels and manganese showed an inhibitory effect in this parameter. Aflatoxin and manganese caused increases in serum cholesterol and together the two compounds interacted synergistically.

ELECTROPHORETIC DIFFERENTIATION OF STRIPED BASS SPAWNING AGGREGATES FROM KERR RESERVOIR, VA. G. J. Buse*, J. J. Ney, and B. J. Turner*. Dept. of Fisheries and Wildlife Sciences and Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The self-sustaining striped bass population of Kerr Reservoir spawns in both the Roanoke and Dan Rivers. This study was undertaken to determine if genetic variation, indicative of reproductive isolation, occurred between the two spawning aggregates.

The enzyme products of fifty structural loci were surveyed in 18 individuals collected from each river in 1979. Of these, creatine kinase, inorganic pyrophosphatase and inosine triphosphatase were found to be polymorphic. Eighty specimens from each river were then analyzed to determine banding patterns for these three enzymes. Each isozyme conformed to Hardy-Weinberg equilibrium and was independent of sex and age. Allele frequencies differed significantly ($P < 0.05$) between rivers for all three loci.

The 1980 spawning runs will be similarly analyzed to further determine the degree of reproductive isolation. The existence of discrete subpopulations of striped bass in Kerr Reservoir has implications for effective management of both the fishery and the spawning streams.

ISOELECTRIC FOCUSING STUDIES OF HUMAN SEMINAL PLASMA

PROTEINS. H. Scott Hardison, James H. Yuan, and J. W. G. Wortham, Jr., Departments of Biological Sciences and Chemical Sciences, Old Dominion University, Norfolk, Va., 23508.

The isoelectric focusing technique has been adapted for the analysis of human seminal plasma proteins. Protein subunits were separated according to their unique isoelectric points in a 7% acrylamide gel containing 9M urea and 2% ampholyte in which a stable pH gradient of 4.5 to 8.5 has been formed. The effects of time, and frequency of emission on banding patterns were studied. Deviation in banding patterns were correlated with basic semen parameters. The establishment of a normal protein "profile" may enable detection of abnormal protein constituents in patients undergoing fertility examination. By separating, isolating, and identifying both normal and abnormal protein species, insight may be gained regarding the molecular nature and relationship of these proteins to fertilization.

A HABITAT EVALUATION SYSTEM DEVELOPED FOR THE EASTERN

WILD TURKEY. P. R. Johansen*, A. R. Tipton*, J. B. Whelan* Dept. of Fisheries and Wildlife, Va. Polytechnic Inst., Blacksburg, VA. 24061

A system is described which quantitatively evaluates potential habitat suitability for the eastern wild turkey in the Piedmont and coastal plain regions of southeastern United States. The procedure utilizes quantitative data on both macro and micro-habitat parameters which are considered critical for the survival, growth, and reproduction of the eastern wild turkey. These key environmental parameters include: availability of roosting sites, diversity of tree species, competition for food resources, proximity to water, proximity to forest clearings, mast availability, and degree of interspersed cover types. An algorithm has been developed using these factors to calculate habitat suitability. Habitat parameters, considered essential for the evaluation, are assigned a weighted value reflecting the relative importance of that factor to the eastern wild turkey. In addition, each habitat parameter is subdivided into categories of intensity and assigned relative values, corresponding to the actual habitat condition recorded in the forest inventory. The appropriate intensity values are multiplied by their respective importance values for each habitat parameter. These products are then summed to produce an overall habitat rating for each area under investigation.

MENINGOENCEPHALITIS IN MICE FOLLOWING INTRAVENOUS

INOCULATION WITH *NAEGLERIA FOWLERI*. D. T. John. Dept. Microbiol., Va. Commonwealth Univ., Richmond, VA 23298. The natural route of infection for *Naegleria fowleri* is by way of intranasal (IN) invasion. Nonetheless, mice can be killed by *N. fowleri* introduced through various other routes of inoculation. This report describes the histopathologic changes and eventual fatal meningoencephalitis for mice inoculated intravenously (IV) with *N. fowleri*. Male DUB/ICR mice weighing 13-18 g were inoculated IV with 2.4×10^6 LEE strain *N. fowleri* (LD_{50} dose). H & E-stained tissue sections were prepared on days 1, 3, 5, 8, 12, 16 and 21 after inoculation. The disease was characterized by amebic invasion of the brain, hemorrhagic necrosis, edema, and meningeal and perivascular leukocytic infiltration. An initial mononuclear cell response gave way to a polymorphonuclear leukocytic infiltrate in areas of necrosis. Although amebae were detected in tissues other than brain, pathologic involvement of these tissues was minimal. Mice inoculated IV with *N. fowleri* died from meningoencephalitis in the same way as mice inoculated IN.

DISTURBANCES OF SEROTONIN SYNTHESIS IN MICE ACUTELY DEPRIVED OF TRYPTOPHAN. M. Jones*, B. Weekley, and D. Kimbrough. Dept. of Biology, Va. Commonwealth Univ., and Dept. of Physiology, Med. Col. of Va., Richmond, Va. 23219

The effect of dietary tryptophan (TRP) on Brain and duodenal serotonin (5-HT) synthesis rates, liver protein levels, blood TRP, albumin and free fatty acids was investigated. Brain 5-HT synthesis was depressed in tryptophan deprived (TD) mice while duodenal 5-HT synthesis was enhanced. Liver protein was initially depressed in TD mice but increased following a tryptophan load. Blood tryptophan and albumin was depressed in TD mice while free fatty acids were not significantly different. Our results suggest (1) that tissue 5-HT synthesis rates and protein levels are altered in tryptophan deprived mice and (2) that the duodenum and liver may liberate TRP during periods of TRP deficiency to maintain blood and brain TRP levels.

THE DISPERSION OF HATCHERY-REARED RAINBOW TROUT STOCKED IN A VIRGINIA MOUNTAIN STREAM. W. T. Kendall*, and L. A. Helfrich*. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Dispersal patterns of 578 tagged rainbow trout stocked into pool and riffle habitats of Big Stony Creek, Giles County, Virginia, were determined from voluntary tag returns and a creel census of fishermen during the 1979-80 trout fishing season. Twenty-two percent of the trout remained within the original 30 meter stocking location; 45% of the trout moved downstream while 33% moved upstream. Trout moving downstream traveled significantly further ($p < 0.001$) than those trout moving upstream. Fifty percent of the marked fish were caught within 240 meters of the stocking location. There was no significant difference ($p = 0.362$) between the median distance moved of trout stocked in pools and those stocked in riffles.

Three major physical factors (residence time, stream temperatures and stream flow rates) were found to strongly influence stocked trout dispersion. The distance trout moved was directly correlated ($r = 0.501$, $p < 0.0002$) with the amount of time in the stream. During stream conditions of low water temperatures and high flow rates, trout dispersion increased. Angling pressure did not affect ($p = 0.3264$) the movement of hatchery-reared rainbow trout.

TISSUE LEAD CONCENTRATIONS AND BLOOD CHARACTERISTICS OF ROCK DOVES. Ronald J. Kendall*, W. B. Norhead*, J. T. Jones* and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Bone and liver lead concentrations ($\mu\text{g/g}$, d.w.) were determined by atomic absorption spectrophotometry in 39 rock doves (*Columba livia*) collected from Blacksburg, Virginia. The blood enzyme, delta-aminolevulinic acid dehydratase (ALAD) was measured in each rock dove. Regression analyses ($r^2 = 0.69$) indicated that ALAD activity decreased as liver lead concentrations increased (log liver lead = $1.76 - 0.013X$). Overall mean (\pm S.E.) liver lead concentrations was 2.11 ± 0.41 $\mu\text{g/g}$ (range of 0 - 11.2 $\mu\text{g/g}$). Overall mean (\pm S.E.) bone lead concentration was 103.06 ± 25.02 $\mu\text{g/g}$ (range 6.63 - 727.86 $\mu\text{g/g}$) suggesting elevated lead exposure in this species, probably related to chronic low-level lead ingestion of contamination of grit particles obtained from roadsides. The rock dove appears to be a useful species for monitoring lead contamination of urban areas. ALAD activity measurements of blood samples collected from live birds or assaying of lead concentrations in bone and liver appear to be the appropriate characteristics for monitoring purposes.

LEAD CONCENTRATIONS IN RUFFED GROUSE COLLECTED FROM SOUTHWESTERN VIRGINIA. R. J. Kendall*, G. R. Norman*, and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

Lead concentrations ($\mu\text{g/g}$, d. w.) were determined by atomic absorption spectrophotometry in the livers and tarsometatarsus bones of 16 ruffed grouse (*Bonasa umbellus*) collected from southwestern Virginia. Overall mean (\pm S.E.) lead concentrations in tarsometatarsus bones was 2.78 ± 0.57 $\mu\text{g/g}$ and values ranged from 0.44 - 9.19 $\mu\text{g/g}$. In the livers, there was a mean (\pm S.E.) lead concentration of 2.27 ± 0.43 $\mu\text{g/g}$ and values ranged from 0.36 - 6.83 $\mu\text{g/g}$. Liver lead concentrations provide an index of acute, high exposure to lead and in the grouse studied did not indicate high lead ingestion. No evidence of ingested lead shot was found in the grouse. Lead concentrations in bones of ruffed grouse were generally low and probably reflected only limited exposure to lead. Ruffed grouse appear to be suitable monitors of the relatively isolated ecosystems they inhabit in southwestern Virginia.

SUBUNIT STRUCTURE OF HEMOCYANIN FROM THE CRAB, *CALLINECTES SAPIDUS*. William K. Latham* and James E. Dondinger. Dept. of Biology, James Madison Univ., Harrisonburg, VA. 22807

Crab hemolymph was electrophoresed on polyacrylamide gel at pH 8.3 and stained for protein with Coomassie blue. Four minor bands were evident at the cathodal end of the gel: two diffuse bands in the mid-portion and three major bands with two minor bands at the anodal end. Electrophoresis of lyophilized hemocyanin resulted in the disappearance of the two middle bands and intensified staining of the three major anodal bands.

Gel filtration of hemocyanin on a calibrated Sephacryl S-300 column at physiological pH yielded two protein peaks which had apparent molecular weights of 670,000 and 450,000 daltons. Each of these proteins were treated with a low ionic strength buffer at pH 10 containing EDTA to chelate divalent cations, and subsequently re-chromatographed. The first protein dissociated into what appears to be a single homogeneous particle with an apparent molecular weight of 67,000 daltons. When the 450,000-dalton protein was re-chromatographed at these conditions, it yielded two particles. One was an aggregate with an apparent molecular weight of 940,000 daltons and the other appeared to be a homogeneous particle with an apparent molecular weight of 65,000 daltons.

DAILY ACTIVITY RHYTHMS IN SYNAPTOMYS COOPERI AND MICROTUS PENNSYLVANICUS. A. Lindsey, Dept. of Biology, Va. Polytechnic Inst., Blacksburg, VA. 24061

The lemming mouse (*Synaptomys cooperi*) and the meadow vole (*Microtus pennsylvanicus*) frequently co-exist in the same habitats. Field data indicate that the two species differ in their daily activity rhythms, with *Synaptomys* exhibiting a greater degree of nocturnality. Of 335 trap-captures of *Microtus*, 156 (47%) were during the nocturnal (includes crepuscular) time period, while 179 (53%) occurred during the day. *Synaptomys* were trapped 49 times, 40 of which were nocturnal captures (82%). On a seasonal basis, *Microtus* demonstrated considerable variability, with the percentage of nocturnal captures ranging from 22%-62%. This species expressed the highest degree of nocturnality between July and September (63%) and the lowest degree between October and December (22%). *Synaptomys* exhibited little seasonal variability, with the percentage of nocturnal captures ranging from 75%-100%.

Laboratory assessment of activity patterns involved quantification of wheel-running behavior under 16L8D at 18°C. Results generally confirmed field observations, with *Synaptomys* averaging about 80% of activity during hours of darkness as compared with about 55% for *Microtus*. While *Synaptomys* exhibited a single major activity peak during darkness, *Microtus* tended toward bimodality during this time frame.

INFLUENCE OF LEAD INGESTION ON REPRODUCTIVE CHARACTERISTICS OF MALE JAPANESE QUAIL. Susan M. Muth, Patrick F. Scanlon, Wanda B. Morehead and Francis C. Gwazdauskas, Dept. Fisheries and Wildlife Sci., Va. Polytechnic Inst. and State Univ. Blacksburg, VA. 24061.

Ninety adult male Japanese quail (*Coturnix japonica*) were assigned to treatments in a 2 x 3 factorial experiment with food intake (ad libitum or restricted to 15g daily) and lead dosing (0; 40 µg/kg body weight weekly, 80 µg/kg body weight weekly) as factors. Lead was given by intubation on days 1, 7 and 14. Body weights and foam gland dimensions were taken on Day 1 and again on Day 21 when birds were killed. At this time testes weights, liver weights and blood serum samples for testosterone assay were taken. Testosterone was assayed by radioimmunoassay. Body weights tended to decrease in lead treated birds and was greater in food restricted birds. Foam gland measurements tended to decrease to a greater extent in food restricted birds. Testes weights and liver weights appeared unaffected by lead treatments and food restriction. Testosterone values appeared variable and did not follow a readily discernable pattern.

EARLY LIFE HISTORY OF ALEWIFE (ALOSA PSEUDOHARENGUS) IN A VIRGINIA RESERVOIR. A. A. Nigro* and J. J. Ney, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

Andromous alewife are being widely introduced in southeastern reservoirs as a forage species. One of the first such populations was established in Claytor Lake, a main-stream impoundment in western Virginia. Study of this population a decade after establishment characterized its reproduction, early growth and food habits. Spawning occurs from May through July in shallow bays over sand. Larvae feed almost exclusively on zooplankton and, like adults, are extremely size-selective. By 85 mm, larval food habits are indistinguishable from adults (150-225 µm).

Due to their rapid growth, alewife are limited as prey for sport fish to young-of-the-year. The extended spawning season assures an accessible alewife forage base throughout the growing season.

SEASONAL CHANGES IN BODY AND WING FAT CONTENT OF RUFFED GROUSE IN SOUTHWEST VIRGINIA. G. W. Norman*, and R. L. Kirkpatrick, Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

Either nine or ten ruffed grouse (*Bonasa umbellus*) were collected in each of the four seasons in southwest Virginia and analyzed for fat composition in evaluation of nutritional status. The feathers, head, feet, major organs and intestines were removed. Mesentery fat was separated from the intestines and returned to the body cavity. Wings were removed at the humerus-scapula-coracoid junction. Carcasses and wings were homogenized and then lyophilized for approximately 96 hours. Ground carcasses and wings were analyzed for crude fat in a Soxhlet apparatus for 18 hours. Mean fat content (±SE) of the carcasses increased from summer (4.3±0.1%) to the fall (12.9±1.3%) and peaked in the winter (16.4±1.6%). Mean fat content dropped sharply from the winter to the spring (4.8±0.3%). Wing fat content was significantly correlated ($r=0.75, P<0.0001$) to that of the body fat in all seasons. Correlations between carcass and wing fat for each season were: summer $r=0.68 (P<0.029)$; fall $r=0.89 (P<0.001)$; winter $r=0.86 (P<0.002)$ and spring $r=0.82 (P<0.006)$. The transition period from winter to spring is hypothesized to be the more nutritionally stressful season of the year for ruffed grouse in southwest Virginia.

SEASONAL VARIATION IN SERUM TRIIODOTHYRONINE (T3) AND THYROXINE (T4) CONCENTRATIONS OF ADULT MALE WHITE-TAILED DEER. Anne Oelschlaeger, Robert J. Warren, Patrick F. Scanlon, Roy L. Kirkpatrick and Francis C. Gwazdauskas, Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State University, Blacksburg, VA. 24061

Seven male white-tailed deer *Odocoileus virginianus*, age 2 years, were placed on a one-year experiment starting in March, 1978. Deer were randomly assigned to individual pens and treatment (diet) groups, either ad libitum consumption or restricted (75% of the average consumption of the ad libitum group). At 28-day intervals deer were immobilized with xylazine hydrochloride and bled by jugular venipuncture on 13 sampling days during the year. Hormone values were determined by radioimmunoassay of blood serum. Serum T4 for all animals was highest ($P<0.05$) in May (205±25 ng/ml) and July (208±14 ng/ml), and lowest in November (136±22 ng/ml). Serum T3 was highest from May-August (range, 2.11±0.13 to 2.44±0.12 ng/ml), and lowest in November (0.90±0.09 ng/ml). Changes in hormone concentrations reflected similar changes in body weight and feed consumption over the year. (Supported by the John Lee Pratt Animal Nutrition Foundation)

DIURNAL VARIATIONS IN TRIIODOTHYRONINE (T3) AND THYROXINE (T4) IN WHITE-TAILED DEER. Anne Oelschlaeger, David F. Gibson, Patrick F. Scanlon, Roy L. Kirkpatrick and F. C. Gwazdauskas, Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061

A 2 year old male white-tailed deer *Odocoileus virginianus*, was fitted with a jugular catheter and bled every 2 hours during four 24-hour periods at intervals of 2 weeks to ascertain the periodicity of thyroid hormone concentrations in blood serum. Radioimmunoassay techniques were employed to determine the circulating concentrations of triiodothyronine (T3) and thyroxine (T4). Mean (±S.E.) serum concentrations were calculated by 2-hour period over the 4 sampling sessions. Data were variable, but an overall pattern was apparent. Visual examination of plotted values revealed that the temporal fluxes in circulating concentrations of the two hormones were similar. Nadir values for both T3 (1.27±0.18 ng/ml) and T4 (142±8 ng/ml) occurred at 1000 hours. The T3 concentrations appeared to fall to low values more steadily than did the T4. These results support the hypothesis of the existence of a diurnal pattern in circulating concentrations in thyroid hormones in this species. (Supported by a grant from the John Lee Pratt Animal Nutrition Foundation).

EFFECTS OF PHOTOPERIOD ON GROWTH AND DEVELOPMENT IN THE VOLE, *MICROTUS PENNSYLVANICUS*. D. H. Pistole* and J. A. Cranford. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Growth and development in *M. pennsylvanicus* exposed to various photoperiodic treatments is shown to be significantly affected by photoperiod length. Young and subadults maintained under a long (18 h light per day) photoperiod gained weight more rapidly than those maintained under a short (6 h light per day) photoperiod. Body weight of *M. pennsylvanicus* maintained under naturally occurring photoperiod and temperatures appeared to fluctuate as a function of decreasing and increasing day length and as a function of age. Adults lost weight during fall and early winter while subadults gained weight until late fall with growth ceasing in early winter. All animals gained weight after the winter solstice in the coldest month of the experiment (January). Thyroid activity, as reflected by thyroxine levels (T_4 radioimmunoassay), T-125 conversion ratios, thyroidal uptake of injected I-125 and relative thyroid weights, is significantly lower in *M. pennsylvanicus* maintained under a short (6 h light per day) photoperiod than in those maintained under a long (18 h light per day) photoperiod.

LEAD CONCENTRATIONS IN MARYLAND WATERFOWL WITH AND WITHOUT INGESTED LEAD SHOT. Patrick F. Scanlon, Vernon D. Stotts, Richard G. Oderwald, Timothy J. Dietrick and Ronald J. Kendall. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Livers were recovered from 613 individuals of 14 waterfowl species shot by Maryland hunters and lead concentrations were determined by atomic absorptions spectrophotometry. Individual birds were examined for presence of lead shot in gizzards by means of a fluoroscope and designated "positive" if lead shot were present and "negative" if lead shot were absent. Data were compared within species by Wilcoxon rank sum tests between lead shot positive and lead shot negative birds. Mean lead concentrations ($\mu\text{g/g d.w.}$) were significantly ($P < 0.001$) higher in *Branta canadensis* (32.1±9.0 vs 5.0±0.5), *Anas platyrhynchos* (43.2±12.8 vs 8.0±1.6) and *Anas rubripes* (36.8±13.5 vs 11.4±4.7) which had ingested lead shot. Only 4 individuals of 11 other species were found to have ingested lead shot. Mean lead concentrations in other species without ingested lead shot were in the range 5.4±1.4 $\mu\text{g/g d.w.}$ in *Bucephala albeola* to 45.9±40.4 $\mu\text{g/g}$ in *Anas aya*.

HEAVY METAL CONCENTRATIONS IN FEATHERS OF RUFFED GROUSE FROM VIRGINIA. Patrick F. Scanlon, Richard G. Oderwald, Timothy J. Dietrick and Joe L. Coggins. Dept. Fisheries and Wildlife Sci., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Concentrations of lead (Pb), cadmium (Cd), nickel (Ni), zinc (Zn), Copper (Cu), and Silver (Ag) were determined by atomic absorption spectrophotometry in feathers of 130 ruffed grouse (*Bonasa umbellus*) shot by hunters in Virginia in 1977-78 and 1978-79 seasons. Mean concentrations ($\mu\text{g/g d.w.}$) of elements were compared between sexes, ages (adults vs juveniles) and seasons of collection.

Overall means ($\pm \text{SE}$) for each element were as follows: Cd, 0.74±0.69; Pb, 6.38±1.91; Ni, 0.05±0.03; Zn, 93.88±0.69; Cu, 4.15±0.20; and Ag concentrations were all below detection limits of 0.1 $\mu\text{g/mL}$. There were no significant ($P < 0.05$) differences between sexes and age categories in any of the elements. A significant difference ($P < 0.05$) between years was noted in Pb.

THE USE OF ISOLATED LEAF CELLS AND PROTOPLASTS AS TOOLS FOR INVESTIGATING PHOTOSYNTHESIS. J. C. Servaites*. Dept. of Biology, VPI&SU, Blacksburg, Va. 24061

Mesophyll cells and protoplasts (cells without cell walls) can be isolated from leaves of a number of species using macerating and cellulytic enzymes. Gentle rupture of the plasmalemma of protoplasts results in the liberation of intact chloroplasts into the break medium. Rapid purification of these chloroplasts is afforded by centrifugation of the chloroplasts through a solution of colloidal silica. Both preparations of cells and chloroplasts have initially the same high rates of photosynthesis, but cells can maintain these rates of photosynthesis for hours and even days, whereas chloroplasts maintain these rates for only a few minutes. The radioactive products of cells after photosynthesis in an atmosphere of $^{14}\text{C}_2$ are much more diverse than in isolated chloroplasts indicating that cells also carry on other metabolic activities (mitochondrial respiration, photorespiration, protein synthesis, etc.) which utilize and metabolize the products of photosynthesis. Inhibition of photorespiration and mitochondrial respiration with chemical inhibitors inhibits photosynthesis in cells, but not photosynthesis of isolated chloroplasts indicating that some pathways of cellular metabolism may be required to maintain chloroplast photosynthesis. Studies of the inhibition of the photorespiratory cycle indicate that under atmospheric CO_2 and O_2 concentrations as much as 50% of the carbon fixed in photosynthesis may enter this pathway.

BLACK SUPPRESSOR MUTATIONS OF *DROSOPHILA MELANOGASTER*. A. F. Sberald. Dept. of Biology, George Mason Univ. Fairfax, Va. 22030

The second chromosome mutation black is characterized by a deficiency in β -alanine synthesis (Hodgetts, 1972, *J. Insect Physiol.* 18:937-947) which produces an interesting temporal, phenotypic dichotomy; abnormally light pupa cases and darkly pigmented adults. The mechanism of β -alanine involvement in these phenes has yet to be defined and a number of models have been proposed (Sberald, 1980, *Experientia* 36:143-146).

A screen of over 80,000 chromosomes has yielded 5 X-linked mutations which suppress both the adult and pupal phenotypes of black. All 5 mutations are recessive, and complementation tests reveal that they are alleles. Intracistronic complementation at the locus indicates that the wild allele produces a protein product and that this intergenic suppression is not the result of an altered t-RNA structural gene. Two of the mutations have been tested and found to suppress an independently isolated allele of black. However, they do not suppress ebony; a mutation with phenotypes analogous to black caused by a deficiency in cuticular uptake of β -alanine (Jacobs and Brubaker, 1963, *Science* 139:1282-1283). These data suggest that the suppressors act by restoring normal levels of β -alanine synthesis.

Preliminary mapping of the locus has placed it at the tip of the X very close to scute.

OCCURRENCE OF KEPONE IN WHITE-FOOTED MICE (*PEROMYSCUS LEUCOPUS NOVEBORACENSIS*) ON JAMESTOWN ISLAND, VIRGINIA.

C. Richard Terman, Laboratory of Endocrinology and Population Ecology, Biology Department, College of William and Mary, Williamsburg, Va. 23185 and Robert J. Huggett, Virginia Institute of Marine Science, Gloucester Point, Va. 23062
Significant quantities of Kepone were found in the livers of white-footed mice captured on Jamestown Island, Virginia in the James River. Levels of Kepone were significantly greater than found in the livers of mice of the same species from inland populations captured on the Ecological Study Area of the College of William and Mary, Williamsburg, Virginia adjacent to a tributary of the James River but at a distance of approximately 4.8 km from the river. These data are the first indicating Kepone contamination of small mammals in a terrestrial ecosystem.

EFFECTS OF ESTRADIOL BENZOATE ON THYROID FUNCTION IN ADULT FEMALE RATS. **T. W. Toney, S. M. Ashe*, and L. G. Martin.** Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284

Because of the relatively high frequency of thyroid disorders that have been demonstrated empirically to occur in women at menopause, a great deal of research has been done investigating the possible relationships between thyroid function and female sex hormones. We examined the effects of various dose levels of estradiol benzoate on thyroid weight and I^{131} uptake in several groups of rats. Each group consisted of approximately 10 rats and was maintained on its particular treatment for 16 weeks. It was found that the weight of the gland was largest in ovariectomized rats receiving 40.0 ug. of estradiol daily, 10 times the normal replacement level. I^{131} uptake, however, was highest in rats receiving 4.0 ug. of estradiol daily, the normal replacement level. The lowest level of I^{131} uptake was seen in rats that had been ovariectomized and hypophysectomized. If rats in this condition were also treated with 4.0 ug. of estradiol daily, their uptake levels increased significantly, though still not as high as the rats with intact pituitaries receiving 4.0 ug. of estradiol. The results seem to indicate that estradiol does stimulate thyroid function by both direct stimulation of the thyroid gland and by increasing TSH secretion from the pituitary. (Supported by Faculty-Grant-in-Aid #1-93035 awarded to Loren G. Martin, Va. Commonwealth Univ.)

AGGREGATION BEHAVIOR IN THE LARGE MILKWEED BUG, *ONCOPELTUS FASCIATUS*, AND SMALL MILKWEED BUG, *LYGAEUS KALMI* (HEMIPTERA: LYGAEDIDAE). **S. T. Trumbo* and N. J. Fashing.** Dept. of Biology, Col. of William and Mary, Williamsburg, VA 23185.

It has been reported in the literature that only immature and young adult *Oncopeletus fasciatus* aggregate, and that this behavior is due to an aggregation pheromone. It is also reported that *Lygaeus kalmii* has no aggregation pheromone, and that any aggregations observed in this species were probably due to mutual attraction to abiotic factors, not an attraction to one another. We tested for aggregation behavior in the laboratory using both species of bug, and taking care to control for any abiotic factors which might influence aggregation behavior. Significant aggregation behavior was demonstrated in both immatures and adults of both species, as well as in young and old adults. Aggregations in both species were found to increase in size with time.

The influence of olfaction via the antennae and of vision on aggregation behavior were tested using *O. fasciatus*. Olfaction was found to be of primary importance, and vision may play a secondary role. Also utilizing *O. fasciatus*, an inverse relationship was found between temperature and the tendency to aggregate, and there is some evidence that more aggregation occurs in the dark than in the light.

THE EFFECTS OF GOLD THIO GLUCOSE ON TRYPTOPHAN AND TYROSINE METABOLISM IN RATS. **B. Weekley and R. Jones*** Dept. of Physiology, Med. Col. of Va., Richmond, Va. 23219 and Dept of Biology, Va. Commonwealth Univ., Richmond, Va. 23219

The effect of gold thioglucose on hepatic and cerebral metabolism of tryptophan (TRP) and tyrosine (TYR) was investigated. Gold thioglucose treatments were given to destroy the ventromedial hypothalamus (VMH) or sympathetic center in rats. To observe both the neural (VIA the sympathetic ganglia) and endocrine (VIA the hypothalamic-pituitary axis), acute and chronic treatments were used respectively. The results suggest that hepatic tyrosine aminotransferase (TAT) is under hypothalamic neural control while tryptophan 2, 3 dioxygenase is under endocrine control secondary to adrenal steroids. Cerebral activity of tryptophan 5 hydroxylase and TAT are acutely depressed following gold thioglucose treatment while the chronic response is much less marked.

THE OCCURRENCE OF SPERM ANTIBODIES IN BLOOD SERA AS DETECTED BY THE KIBRICK, FRANKLIN-DUKES AND ISOJIMA TESTS. **J. W. E. Wortham,** Dept. of Biological Sciences, Old Dominion University, A. A. Acosta, Dept. of Obstetrics & Gynecology, Eastern Virginia Medical School, R. J. Swanson, S. B. Ackerman and Kay Taylor*, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Blood serum of suspected infertile couples was tested for the presence of antisperm antibodies. Serum from 11 of the individuals (7.3%) tested were positive for either the Isojima test, Franklin-Dukes test, or Kibrick test and six individuals were positive for more than one test. Nine of the males and 2 of the females contained antisperm antibodies in their blood serum. Sperm immobilizing antibodies detected by the Isojima test were found in 2 males and 1 female. Sperm agglutinating antibodies detected by the Franklin-Dukes and/or Kibrick test were present in 8 males and 1 female. Five of these males were positive for both the Kibrick and Franklin-Dukes tests. Basic semen parameters (e.g., morphology, motility, count, viability) were compared between the antisperm positive males and antisperm negative males.

MID-WINTER HEMATOPOIESIS IN WATER SNAKES (GENUS: *MATRIX*). **William H. Yonke, Jr.,** Dept. of Biology, VPI&SU, Blacksburg, VA 24061.

As an aspect in the continued investigation of reptilian hematology, blood smears were made monthly of eight natri during the period December to May to re-evaluate earlier studies which suggested that this period is one of limited hematopoietic activity. The presence of blastoid, dividing, immature and thrombocytic cells in the peripheral circulation was the parameter for hematopoiesis. All of the natri had been previously challenged with cytotoxidia (-Toddia:Protozoa) and six of them had been positive for varying periods while two (Sip 2 and Sip 3) were refractory. None were cytotoxicid patent during this study period nor had been since March of the year earlier. During the peak of hematopoiesis (June-August and Post-Ecdysis) the hematopoietic cells reach more than 50% of the total cells. During this study period 26% was the highest reached. Four of the snakes had their lowest number of hematopoietic cells in December, 3 in January and 1 in February. Five of the 8 natri shedded during the period; 2 shedded twice. Post-ecdysis was characterized by increased hematopoietic cells but never above 35% of total cells. This work supported the earlier observations and it represents the first report of hematopoiesis in snakes with known cytotoxicid histories.

FISH HOSTS OF THE GLOCHIDIA OF FOUR LAMPSILL MUSSELS IN BIG MOCCASIN CREEK, VIRGINIA. **Alexander V. Zale and Richard J. Neves.** Dept. of Fisheries and Wildlife Sciences, VA Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The reproductive biology of most freshwater mussels is unknown, particularly the required fish hosts for glochidial metamorphosis. Fish hosts of the four lampsill mussel species in Big Moccasin Creek, Virginia were identified by induced laboratory infections and verified through field observations and collections. *Medionidus conradicus* infected the fantail darter (*Etheostoma flabellare*) and the redline darter (*E. rufilineatum*). *Micromya nebulosa* was hosted by the smallmouth bass (*Micropterus dolomieu*) and the rock bass (*Ambloplites rupestris*) while *Micromya vanuxemensis* parasitized the banded sculpin (*Cottus carolinensis*). *Lampsilis fasciola* infected the smallmouth bass. These results indicate that non-game fish species play an essential role in the life cycle of some lampsill mussels. River systems inhabited by species of endangered mussels must therefore be managed to retain their original piscine fauna, at least until appropriate fish hosts for successful reproduction are identified.

Botany

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

NOMENCLATURAL PROBLEMS IN THE PLANT FAMILY MYRICACEAE. J. Rex Baird, Biology Department, Clinch Valley College of the University of Virginia, Wise, Virginia 24293.

The family Myricaceae has been variously regarded as consisting of one or two, or three genera, all of which are represented in the North American flora. Results of recent investigations, including comparative studies of floral and vegetative morphology, support the recognition of three genera, but a study of the nomenclatural history reveals some misapplications of generic names that may necessitate numerous name changes. Studies of the eight species present in North America (north of Mexico) show that several nomenclatural mistakes at the species level have been perpetuated in many major manuals.

AN INTERPHYSIOGRAPHIC ANALYSIS OF HERB AND SHRUB VEGETATION OF VIRGINIA FORESTS. S. J. Blinn. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284.

Thirty upland deciduous stands were sampled from the mid-Coastal Plain to the mid-Piedmont in New Kent, Hanover, and Louisa Counties. Density data for herbs and shrubs was collected, and soil samples were collected in each stand. A cluster analysis of the vegetation data was performed using Euclidean distance and "furthest neighbor" clustering. Four clusters of stands were identified. A cluster of six stands with *Shonymus americanus* as the dominant species was strongly related to the Coastal Plain, but the other clusters were not physiographically associated. Other dominant species in the analysis were *Vaccinium vacillans*, *Gaylussacia baccata*, and *Mitchella repens*.

The soil nutrients most strongly correlated with the dominant species were calcium and magnesium. *S. americanus* and associated species were positively correlated with these nutrients and the ericaceous shrubs were negatively correlated.

VEGETATION/ELEVATION RELATIONSHIPS IN THE MARSH/UPLAND TRANSITION ZONE OF THE CENTRAL ATLANTIC COAST. John D. Boon III, Donna M.E. Ware, and Gene M. Silberhorn, Va. Inst. of Marine Sci. & Dept. of Biol., Coll. of Wm. & Mary, 23185.

Transects were run across the transition at each of five primary sites (one each in s.NC, n.NC, VA, MD, and DL), plus satellite secondary sites. Coverage was estimated for herbaceous plants and basal area was calculated for woody plants. Elevational measurements were taken along each transect and adjusted to refer to the tidal datum of MHW established by the National Ocean Survey. The combined vascular flora for the transition totalled 85 species. About 2/5 of these were vegetationally significant and included species of the adjacent woodland, weedy heliophilic upland species, and marsh species. *Distichlis spicata*, *Spartina patens*, *Juncus roemerianus*, or *Baccharis halimifolia* marked the upper limit of the transition most frequently. These (except *Juncus*), plus *Rhus radicans*, *Panicum virgatum*, and *Iva frutescens* occurred in the transition in all five study regions. In the transition (a) herbaceous plants dominate, the marsh plants reaching their upper limit either just below the woodland or within its edge, or (b) *Baccharis* forms a shrub border contiguous to the woodland, or (c) admixture of herbaceous plants and *Baccharis* and/or *Iva frutescens* occurs.

An elevation for the upper limit of the transition of ca. 40 cm above MHW was typical of the tidally-restricted coastal sound environment, 60-70 cm for tidally open marsh/lagoon environments, and 34 cm for the bay-estuarine environment.

FURTHER ADDITIONS TO THE FLORA OF NORTHERN VIRGINIA. I. R. Bradley, Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

Recent collections from northern Virginia have produced many county records of which a few are also state records. Apparently collected for the first time from Virginia are *Ludwigia uruguayensis* (Camb.) H. Hara (Onagraceae), *Cornus stolonifera* Michaux (Cornaceae) and *Tribulus terrestris* L. (Zygophyllaceae). Also new to the state is *Sida hermaphrodita* (L.) Rusby (Malvaceae) which was previously misidentified as *Napaea dioica* L., which must now be removed from the Virginia flora. A rare second collection of *Verbena bracteata* Lag. and Rodr. (Verbenaceae) from Hog Island is the first collection since originally found in Southampton County in 1893. Also a second location for *Amaranthus lividus* L. (Amaranthaceae) was discovered in Northampton County. Range extensions of interest are *Parapholis incurva* (L.) C. E. Hubbard (Poaceae), the first collection west of the Chesapeake Bay, and *Ludwigia leptocarpa* (Nuttall) H. Hara from Fairfax County which is about 55 kilometers up the Potomac River from King George County where it was found in 1978.

PHYTOCHROME CONTROL OF ROOT GROWTH RATE IN *LEMNA* SPP.

C. P. Chamuris* and P.T. Nielsen. Dept. of Biology, James Madison University, Harrisonburg, Va. 22807

Three strains of *Lemma* (*L. gibba* L., strains G1 and G3; and *L. minor* L.) were studied in order to confirm and extend an earlier report that root growth in *L. gibba* G1 and *L. gibba* G3 is under phytochrome control. Plants were cultured in inorganic growth medium, and were exposed to several low energy light treatment conditions: no treatment (control), 5 min R, 5 min R + 15 min FR, and 5 min R + 15 min FR + 5 min R. These treatments immediately preceded the 14 hr period of darkness. Root lengths were measured at 24, 28, 48, 52, 72 and 76 hrs; and root growth rates were calculated.

Comparison of root growth rates revealed that far-red light treatments (R + FR) inhibited root growth rate. This inhibition was abolished upon subsequent treatment with red light (R + FR + R). This red/far-red photoreversibility strongly suggests that root growth in *Lemma* spp. is under phytochrome control.

THE COMPOSITION AND CONCENTRATION OF PHYTOPLANKTON WITHIN THE VIRGINIA BARRIER ISLAND COMPLEX. S. Cibik*, C. K.

Rutledge*, R. B. Fawley*, and H. G. Marshall. Dept. Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Ten collections of surface phytoplankton were made at eight stations between November 1978 and October 1979 within the channels of the Virginia Barrier Island complex.

A total of 192 taxa were identified, consisting mainly of north and south temperate neritic species. The samples were dominated by nanoplankton sized diatoms, with various dinoflagellates, silicoflagellates, chlorophytes, cyanophytes, and coccidophores present in lesser numbers. The seasonal phytoplankton composition within the channels was similar to composition reported for the continental shelf waters.

Three population maxima occurred in winter, spring, and fall, with four peaks in species diversity noted. Concentrations of total phytoplankton ranged from 13,500 to 2.78 million cells/liter. Species diversity (Shannon's Index) ranged from 2.35 to 4.05. Ubiquitous during the study were *Skeletonema costatum* and *Asterionella glacialis*. Seasonal assemblages of total phytoplankton were identified. The Virginia Environmental Endowment is acknowledged for the support of this study.

A PRELIMINARY STUDY OF SOOTY MOLD GROWTH AND ABUNDANCE NEAR A SMALL DISTILLERY IN RESTON, VA. C. B. Jolley* and A. P. Tortelli*, Dept. of

Biology, George Mason Univ., Fairfax, Va. 22030

Comparisons of growth and occurrence of the predominant dematiaceous fungi were made between distillery, adjacent and non-adjacent sampling sites. To explore utilization of hydrocarbon emissions from the whiskey aging warehouses, additional samples were collected at all sites on Ozaeck-Jox Agar with ethanol added as a sole carbon source.

The predominant dark genera at all sites were *Glabosporium* sp., *Aureobasidium pullulans* (de Bary) Arnaud and *Alternaria* sp. Significant differences in growth and frequency occurred, particularly between distillery/adjacent sites and non-adjacent sites. The three genera grew on ethanol plates from all sites, again with significant differences between sites. Abundant growth on and near the whiskey aging warehouses appears influenced by several environmental factors, contributing to the utilization of hydrocarbon vapors by the fungi present. (Aided by EPA Fellowship U911186)

VASCULAR FLORA OF NATURAL TUNNEL STATE PARK, SCOTT COUNTY, VIRGINIA. Richard V. Davis, Jr.*

Box 193, Coeburn, Virginia 24230.

Natural Tunnel is in the Ridge and Valley province of extreme southwestern Virginia, an area where little systematic collecting has been done. Field work in the state park began in February of 1978 and was concluded in August of 1979. Data concerning anthesis, abundance, and habitat type were noted for all taxa and information on soil types, climate, and geological structure was gathered. Ten vegetation types were recognized on the basis of land use patterns and environmental conditions. A total of 552 species of vascular plants was collected, establishing county records for 97 taxa and range disjunctions for several species. The large number of species reflected the diversity of habitats. The range disjunctions and the number of county records established emphasize the need for further floristic study in southwestern Virginia.

OBSERVATIONS OF PHYTOPLANKTON COMPOSITION ON THE SOUTH-EASTERN CONTINENTAL SHELF. R. B. Fawley*, S. Cibik*, C. K. Rutledge*, and H. G. Marshall. Dept. of Biological Sciences and Oceanography, Old Dominion Univ., Norfolk, Va. 23508.

Surface water bottle samples from 36 stations were collected in September 1978 over the U.S. southeastern continental shelf by the South Carolina Wildlife and Marine Resources Department. Samples (500 ml) were preserved in 5% buffered formalin and processed with a modified Utermohl method utilizing an inverted plankton microscope.

The total number of species identified was 121 with the major taxonomic groups composed of diatoms (87 species) and dinoflagellates (28 species). Other groups represented included the blue-green algae (5 species) and silicoflagellates (1 species). The diatoms were the most abundant and widely distributed group.

Ocellularia erythraea occurred most frequently, being present at 25 stations. The most abundant (# of cells/liter) species were the diatoms *Rhizosolenia alata* f. *indica* and *Rhizosolenia alata*, with *Melosira granulata* var. *angustissima*, *Leptocylindricus denticus*, and *Rhizosolenia alata* f. *gracillima* being present in lower concentrations. The most abundant dinoflagellate was *Prorocentrum micans*. No other dinoflagellate was present in significant concentrations.

It was noted that the blue-green alga *Nostoc commune*, *Ocellularia erythraea* and *Johnnesbaptista pellucida* were commonly found in the nearshore waters.

THE DISPERSAL OF SAMARAS ABOUT AN INDIVIDUAL OF *BETULA UBER* (ASH) FERN. UNDER NATURAL CONDITIONS. R. H. Ford*, T. L. Sharik, and P. P. Feret. Dept. of Forestry, Va. Polytechnic Inst., Blacksburg, Va. 24061

Samaras of a *Betula uber* individual in a forested stand were collected during winter 1979-80 to determine maximum dispersal distance and the temporal dispersal profile. Sixty-four .25m² screen traps, each sampling equal areas, were placed about the seed source along eight 100m long radii of a 3.1 hectare circle. The traps were emptied weekly from mid-December until April. Seed fall was maximum at 25m, decreased linearly from 25m to 66m, and leveled off gradually thereafter. A strong directional component was observed in the dispersal profile with 70% of the samaras being collected in the SE quadrant of the study area. This directional component may be caused by a prevailing NW wind. Over 50% of the samaras were dispersed during January, with a peak rate (34% of the total seedfall) occurring during the week ending January 25. A second peak representing over 25% of the total samaras was observed in mid-February. The peaks were associated with periods of moderate to warm temperatures.

NUTRIENT CONTENT OF LITTERFALL: A STUDY OF FOUR PLANT COMMUNITIES IN THE GREAT DISMAL SWAMP, VIRGINIA. Marta Gomez* and Frank P. Day, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

The nutrient content of the litterfall in four plant communities in the Great Dismal Swamp, Virginia was studied. These stands differ in species composition and flooding regime. The elements analyzed were N, P, K, Mg and Ca. Leaf fall of plant species found at the cypress community exhibited a higher percent concentration of the nutrients analyzed except Ca. The cedar stand showed lower concentrations of the mobile elements in the leaf litterfall. Nutrient deposition was greatest in the maple-gum and cypress communities, which reflects the higher leaf fall rates at these two sites. Nutrient analysis of small woody litter was also conducted.

CHROMOSOMAL EVOLUTION IN THE GENUS *ASTER* (ASTERACEAE). L. Michael Hill, Department of Biology, Bridgewater Coll., Bridgewater, VA 22812.

The purpose of this investigation is to consider the chromosome number of species of the genus *Aster* (Asteraceae) in the Middle Atlantic United States. Although there is much chromosome data on *Aster* sp. from North America, it is lacking in species found in the Virginias and Carolinas. This report concerns the chromosome numbers of *Aster novae-angliae* L., *A. cordifolius* L., *A. pilosus* Willd., *A. linearifolius* L., *A. acuminatus* Michx. and *Aster oblongifolius* Nutt. These data will be compared with reports from other sources and will be put within the context of chromosomal evolution of the Genus as a whole. *Aster* is known for its morphological complexity. The genus is also complex from a cytological point of view.

STUDIES IN THE VIRGINIA FLORA: PHRYMACEAE AND PLANTAGINACEAE. Wiles E. Johnson, Department of Biology Virginia Commonwealth University, Richmond, VA 23284.

Phrymaceae, a monotypic family, and Plantaginaceae with nine species in Virginia are studied floristically. A new key to Virginia *Plantago*, descriptions, ecologic data and distribution maps are presented.

Plantago wrightiana Dcne. is reported new to the flora and *Plantago cordata* Lamark is verified as present in the flora.

THE VASCULAR FLORA OF LITTLE STONEY CREEK, SCOTT COUNTY, VA. Dwight E. Peake*, Dept. of Biology, Col. of William and Mary, Williamsburg, VA 23185.

Little Stoney Creek is part of the Tennessee Valley drainage system and is in the extreme northwest corner of Scott County, Virginia. The stream is at the eastern edge of the Appalachian Plateau Province on Pennsylvania Age strata in the Cumberland Mountains. A section one-half mile wide on each side of the stream from Bark Camp Lake to Hanging Rock encompasses a study area of approximately 14 square miles within the Clinch Ranger District of the Jefferson National Forest. Collection of the vascular plants began in May, 1978 and continued until April, 1980. Major community types present in the study area are mixed deciduous woods, mixed deciduous-pine woods, lake and stream edge, and disturbed areas. A total of 480 species of 271 genera of 92 families has been collected and identified, and many are Scott County and Virginia Appalachian Plateau Province records. Some of the more interesting taxa include *Isoetes engelmannii*, *Lygodium palmatum*, *Habenaria peramoena*, *Liparis Toesellii*, *Callitriche heterophylla*, *Myriophyllum heterophyllum*, *Leucothoe axillaris* var. *editorum*, *Aster surculosus*, *Heterotheca nervosa* var. *nervosa*, *Helianthus atrorubens*, and *Liatis spicata*.

A VEGETATIONAL ANALYSIS OF THE NORTHEASTERN NORTH CAROLINA OUTER BANK'S MARSHES, J. E. Perry* and F. P. Day, Jr. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Seasonal productivity and plant association similarities were measured for six brackish marsh sites in the North Carolina Outer Banks. Three randomly chosen 1/4 m² plots were clipped at ground level from each site on a biweekly interval and returned to the lab. Each sample was separated into species, oven dried and weighed. A total of 38 species was collected from the sites. Five plant associations and three site groups were defined using a Czekanowski quantitative classification index. Sites 2, 3 and 6 formed group 1 dominated by a *Juncus-Eleocharis* association. Co-dominant associations of *Spartina-Mikania* and *Juncus-Eleocharis* were found in both sites 1 and 5 forming group 2. Group 3 consisted of site 4, an area recently exposed to dredge and fill activity.

CHARACTERIZATION OF PUROMYCIN DISSOCIATED MAIZE RIBOSOMES. W.C. Phelps, E. R. Stout, A. Eesen. Dept. of Biology, V.P.I. and S.U., Blacksburg, VA. 24061

Over the past decade, prokaryotic and eukaryotic ribosomes have been the subject of extensive biochemical, biophysical, and functional characterization. However, comparative data from plant systems is sparse and surprisingly variable. For example, the total number of cytoplasmic ribosomal proteins reported in plants varies from a low of 44 in barley to a high of 99 in peas. In view of the functional complexity of ribosomes, such evolutionary variation is highly unlikely and is presumably due to experimental inadequacies.

An effective procedure for subunit isolation has been established that is based on cytoplasmic monomer dissociation by puromycin/GTP pre-incubation and exposure to 250 mM KCl. The large 60S and small 40S subunits isolated were then characterized with respect to purity of preparation, structural integrity, and functional activity as measured by poly(U) directed *in vitro* translation. Ribosomal proteins were then extracted from each subunit and analyzed by a modification of the two-dimensional polyacrylamide gel electrophoretic procedure of O'Farrell.

OBSERVATIONS OF A DIAPORTHE-LIKE FUNGUS ON METROSIDEROS COLLINA. Martha K. Roane and F. R. Fosberg, Dept. of Plant Pathology & Physiology, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061, and National Museum of Natural History, Smithsonian Institution, Washington, DC 20560.

Ohia, *Metrosideros collina* ssp. *polymorpha*, the principal indigenous forest tree of the Hawaiian islands, is also a pioneer species on new lava flows. Ohia decline, which has affected stands totalling about 100,000 acres, has been associated with nutrient deficiencies and Phytophthora root rot. However, we have found that a *Diaporthe*-like fungus fruits shortly after the trees die and produces carbonaceous stromata with one olive-green fertile layer containing perithecia and a second marbled olive-green and white interior layer extending as a foot into the host. Ascospores are hyaline, one-celled, allantoid with one to several refringent globules. On malt agar, Phomopsis-like α and β conidia are produced in olive-green stromata with conical locules opening through a pore. The pathogenicity of this fungus has not yet been determined.

AGE-STRUCTURAL RELATIONSHIPS IN AN APPALACHIAN OAK FOREST IN SOUTHWEST VIRGINIA. M. S. Ross*, T. L. Sharik, and D. W. Smith*, Dept. of Forestry, Va. Polytechnic Inst., Blacksburg, VA 24061.

The age structure of all tree species in seven Appalachian oak stands in southwestern Virginia was determined. Aging of small individuals was done by counting terminal bud scars or by counting rings in cores extracted with a micro-increment bore. Aging of large individuals involved counting rings on stumps immediately after the stands had been clearcut. Total age structure in all stands did not differ significantly, and had the following pattern: (1) A regular decrease in density with age in the 0-20 age classes, (2) A gap in the 20-40 year age classes in which density was relatively low, and (3) A series of density peaks in the 40-80 year age classes associated with extensive harvesting, frequent fire, and the demise of American chestnut. Differences in species behavior were not obvious, and generally adhered to the above pattern. Because of poor correlations found between diameter and age, it was suggested that diameter distributions give an imperfect picture of replacement processes in forests. (Aided by USFS and Va. Ag. Fdn.)

PHYTOPLANKTON BIOMASS ESTIMATES RELATED TO PRIMARY PRODUCTIVITY VALUES. C. Rutledge*, R. Fawley*, S. Cibik*, K. Nesius, and H. Marshall, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

The relationship between phytoplankton biomass parameters and primary productivity rates were assessed using multiple regression analysis. Phytoplankton samples taken at eight stations in December, 1978 were analyzed. Carbon fixation rates were determined using a standard ^{14}C method. The following biomass estimates were calculated: a) protoplasmic volumes, b) cellular surface area, c) cellular volumes, d) metabolizing biovolumes, and e) number of cells/liter.

Regression analysis yielded a significant regression equation ($\alpha=.05$) which contained only three of the above parameters. The equation was: $Y=4.78 \cdot 10^{-5}(X_1) + 1.59 \cdot 10^{-7}(X_2) - 2.35 \cdot 10^{-8}(X_3) + 5.60 \cdot 10^{-1}$. Where: Y = carbon fixed (mgC/m³/hr), X_1 = number of cells/l, X_2 = Σ metabolizing biovolumes (um³/l), X_3 = Σ protoplasmic volumes (um³/l). The multiple R for the equation was 0.93 and the multiple R² was 0.86. Part correlation analysis indicates the independent variable X_1 , explains 71.2% of the variance of the dependent variable. Stepwise inclusion of the remaining variables into the equation increased the explained variance by 9.23% and 5.26% for X_2 and X_3 respectively.

There existed a significant regression relationship between primary production to 1) simple cell numbers/l and 2) volumetric parameters which were calculated to reflect more truly the metabolizing biomass in phytoplankton.

CYCLOHEXIMIDE - AMENDED MEDIA FOR THE DIFFERENTIATION OF ENDOTHIA PARASITICA FROM E. GYROSA. R. J. Stipes and J. A. Daubert*, Dept. of Plant Path. and Physiol., Virginia Tech, Blacksburg, VA 24061.

The antifungal antibiotic, cycloheximide (Acti-dione®), produced by *Streptomyces griseus*, was used successfully as an agar medium amendment to differentiate *Endothia parasitica* from *E. gyrosa*. The compound was incorporated in a 0.5% glucose - 0.1% yeast extract - 1.5% agar at concentrations of 1, 2, 10, 25, 50 and 100 μ g/ml. Plates were inoculated with 10 different specimen-vouchered isolates each of *E. parasitica* and *E. gyrosa* which varied in source and host. At 1 μ g/ml, the percent growth inhibition of *E. gyrosa* ranged from 80-95%, while *E. parasitica* showed only moderate inhibition (6-25%). *E. gyrosa* did not grow at concentrations above 2 μ g/ml, while *E. parasitica* had trace growth even at 50 μ g/ml. Similar results were obtained with cycloheximide-amended potato-dextrose agar. This is the first report in which *Endothia* spp. have been differentiated chemotaxonomically with a fungitoxic xenobiotic compound.

A FLORISTIC STUDY OF HOLOCENE LEAF MATS FROM MACON COUNTY, ALABAMA. Donna L. Ship, Biology Dept., George Mason Univ. Fairfax, Va. 22030, and USGS, Reston, Va. 22092

Plant megafossils found in organic rich clay lenses along Uphae Creek in Macon County, Alabama, have radiocarbon ages of 6200 \pm 110 and 7500 \pm 110 y.B.P. These carbonaceous lenses are contained in terrace deposits adjacent to and exposed along the length of Uphae Creek. Generally the seeds and fruits are contained within lenses of sand whereas the leaves are in a matrix of clay. Leaves, fruits and seeds have been isolated and identified by comparing them to herbarium specimens. The leaf flora include *Betula nigra*, *Quercus nigra*, and *Pinus* sp. The seed and fruit fossils, together with the leaves, provide a complete picture of the flora present between 6200 and 7500 y.B.P. The fruits and seeds include specimens from *Liriodendron tulipifera*, *Rhynchospora* sp., and *Carya* sp. A floristic analysis on the paleoflora indicates an oak-hickory-pine forest. This same assemblage is representative of Alabama forests today. If composition can be correlated with climate, then we can assume that today's climate is similar to that between 6200 and 7500 y.B.P.

VASCULAR FLORA OF MATHEWS COUNTY, VIRGINIA. Margaret van Montfrans*, Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185

A floristic study was conducted from June, 1978 to November, 1979 in Mathews County in Virginia's outer Coastal Plain. Mathews County, which covers an area of 105 sq. mi., is in the easternmost section of the Middle Peninsula, and is of predominantly low elevation. The area consists of such habitats as salt water and fresh marshes, swamphoods, mixed pine-deciduous woods, ravines and bluffs, and disturbed areas. A total of 640 species representing 372 genera of 114 families were identified; ten of these species are reported as new for the outer Coastal Plain, while 57 are records for the Middle Peninsula. New species for the county record totalled 463. Noteworthy plants collected include *Salpicchroa origanifolia*, *Eryngium prostratum*, *Euphorbia heterophylla*, *Tussilago farfara*, *Chelone cutbertii*, and *Carya aquatica*.

A vegetational analysis using the Bitterlich method of forest sampling was carried out at two sites in the county. At the forested bluffs site along the Piankatank River, *Quercus prinus* was the dominant species, with *Q. velutina*, *Liquidambar styraciflua*, and *Q. alba* next in order of relative dominance. The second site, a swamphood along North End Branch, revealed *Acer rubrum* dominant, followed by *Liquidambar styraciflua*, *Carpinus caroliniana*, and *Carya aquatica*.

A SYSTEMATIC SURVEY OF SELECTED GENERA OF THE TRIBE HELIANTHEAE IN VIRGINIA. V. M. Terry², Dept. of Biology, Col. of William and Mary, Williamsburg, VA 23185

This study is a systematic treatment of a portion of the Heliantheae, which is considered to be the most primitive tribe of the family Compositae (Asteraceae). Three of the 24 genera occurring in Virginia were examined: *Borrchia* Adanson (1 sp.), *Helianthus* L. (20 sp.), and *Verbesina* L. (3 sp.).

Data was obtained from the examination and annotation of over 1200 specimens from nine herbaria, from extensive observations and collections made in the field, and from the literature. Of those examined, 243 were collected personally in the course of ten collecting trips taken in the late summer and fall of 1979; 88 of the 98 counties of Virginia were visited as a result of these extensive excursions. Voucher specimens have been deposited in the Herbarium of the College of William and Mary.

In addition to a key to the genera selected for treatment, keys to species, descriptions, ecological data, and county-based distributional information have been provided.

DECLINE OF *Pinus strobus* L. ON LANDSCAPES IN VIRGINIA. M. J. Weaver*, R. J. Stipes and D. F. Amos. Depts. Plant Pathol/Physiol. and Agronomy, Va. Tech, Blacksburg, VA 24061

A decline of Eastern white pine (*Pinus strobus* L.) has been observed for a number of years in Virginia and across the eastern U.S. Within the past 5 yrs, apparent increased incidence of the disorder noted by homeowners, landscapers, nurserymen, extension agents and others, plus the increased costs of replacing these trees, have warranted an investigation into the causal factors of the decline.

A group of 100 test trees, ranging from healthy controls to trees in various stages of decline, has been studied intensively at various locations in Virginia. A systematic disease indexing method was developed and followed for each tree in the study. Data were collected on tree growth, various chemical and physical soil factors, associated abiotic and biotic agents, and on rhizosphere and root zone indicators.

Results implicated the following interacting complex of factors: high soil pH (7.0-8.5), heavy soil texture, high amounts of competition and shading, root impedance, physically disturbed soil horizons, soil compaction, various secondary biotic agents, and various other abiotic stresses, primarily moisture stress and O₂ tension.

Thus far, no one factor is suspected as being the primary causal agent contributing to decline. Poor quality growing sites, however, on which this sensitive species is planted, appear to be involved in an overall and primary way.

VASCULAR FLORA OF THE BURWELL BAY AREA, ISLE OF WIGHT COUNTY, VIRGINIA. L. L. Whitmarsh, Col. of William and Mary, Williamsburg, Va. 23185

The Burwell Bay area is a twenty square mile area located in northeastern Isle of Wight County, Virginia. This county is located in the Inner Coastal Plain region of Virginia. Collections of the vascular flora began in April of 1979 and continued until April of 1980, being conducted at least once weekly throughout the growing season. Voucher specimens have been deposited in the Herbarium of the College of William and Mary.

The major plant communities present include 1) freshwater marshes 2) saltwater marshes 3) sand and marl areas 4) bottomlands 5) pine-deciduous woods 6) deciduous woods 7) recently disturbed areas.

A total of 559 species representing 340 genera of 108 families have been recorded from the Burwell Bay area. Two hundred and twelve have not previously been reported in the literature as occurring in Isle of Wight County. Species of interest include *Eleocharis parvula*, *Copallorhiza odontorrhiza*, *Monotropa hypopitys*, *Viburnum acerifolium*, *Erigeron bonariensis*, and *Senecio vulgaris*.

RECENT INCREASE IN THE ABUNDANCE OF RED CEDAR JUNIPERUS VIRGINIANA L.) IN VIRGINIA EAST OF THE BLUE RIDGE. E. Spencer Wise, Dept. of Biology and Environmental Science, Christopher Newport Col, Newport News, Va. 23606.

Over the past 30 years there has been a steady, visible increase in the abundance of *Juniperus virginiana* in abandoned fields of Piedmont Virginia, where this species has appeared with *Pinus virginiana*, *P. echinata*, and *P. taeda* as the first woody successional species. On many disturbed areas, such as fills and embankments, red cedar has been the only woody pioneer. During the past 10 years the rate of spread of this species has accelerated, and it has become established in managed permanent Piedmont and Coastal Plain pastures. It is also appearing in *Pinus taeda* plantations in the Piedmont that are less than 10 years old.

Red cedar is appearing with increasing frequency in abandoned fields of the Coastal Plain, even when seed-producing trees of *Pinus virginiana* or *P. taeda* are nearby. Some of these abandoned fields have over 75% red cedar and will become red cedar forests, as will many old fields in the Piedmont. Only 3 red cedar forests with trees of saw size, all in the Piedmont and all 10 acres or less, could be located.

This increase in red cedar populations may be a resurgence. It was a successional species in the 1700's and a commercial forest species in the 1800's in the Piedmont. There are indications of a decline which persisted from the turn of the century into the 1930's.

Chemistry

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

CYCLOBUTEREDIONE-OXYCARBENE REARRANGEMENT. W. B. Barham, S. C. Clough, J. D. Myers, and D. A. Clabo, Dept. of Chem., U. of Richmond, Va., 23173 and A. Johnson, L. Jaques, and J. Forehand, A. H. Robins Company, Richmond, Va., 23220.

The photolysis of 3, 4-diphenyl-3-cyclobutene-1,2-dione in the presence of cyclopentadiene results in the formation of an adduct which suggests the intermediacy of a carbene. A structure proof of the adduct and a comparison of the thermal and photochemical behavior of the dione are discussed, including mechanistic implications of the various reactions.

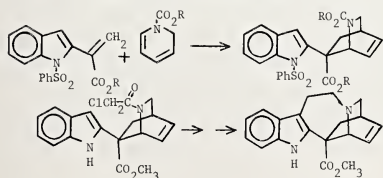
COMPUTER-GENERATED PROBLEM SETS--A FLEXIBLE TOOL FOR CHEMISTRY INSTRUCTION. James D. Beck, Dept. of Chemistry, Virginia State University, Petersburg, VA 23803

Computers are now being used in chemical education in many different ways. One popular use is for interactive exercises such as tutorials, simulations, and drill-and-practice work. The availability of inexpensive microcomputers, some with graphics capability, has spurred the growth of this kind of computer-based instruction. At Virginia State University we have been using the computer in this interactive mode and also to generate individualized problem sets and examinations. Recently we have tied these two types of computer use together in the form of computer-generated problem sets which are checked and graded by means of an interactive program.

The problem sets are generated by a BASIC program with the answers to the questions stored for retrieval later, by either the student or instructor. The student solves the problems off-line; this permits flexibility in terms of the types of questions that can be asked and removes the constraint of computer time which may limit interactive computer use. Having worked out the answers to the questions, the student accesses an interactive program that checks the answers and provides additional information. This allows the usual advantages of interactive computing, including immediate feedback, detailed explanation of answers and methods, diagnosis of areas of difficulties, and prescription of activities which can aid the student.

CHLOROACETAMIDE PHOTOCYCLIZATION. SYNTHESIS OF 20-DESETHYL CATHARANTHINE.¹ Richard J. Sundberg and Jonathan D. Bloom, Dept. of Chemistry, Univ. of Va, Charlottesville, Va. 22901

20-Desethylcatharanthine, a potential precursor of vinblastine-type dimeric indole alkaloids, has been synthesized in 10 steps from 1-benzenesulfonylindole. The synthesis features a Diels-Alder reaction between 1-carboethoxy-1,2,-dihydropyridine and ethyl 2-(1-benzenesulfonylindol-2-yl)acrylate to construct the 7-carboethoxy-7-(2-indolyl)isoquinclidine skeleton and photocyclization of an N-chloroacetyl derivative to introduce the C-5-C-6 (tryptamine) bridge. Reduction of the lactam is achieved via the thiolactam. With isolation of six intermediates the overall yield is 5% from 1-benzenesulfonylindole.



DERIVATIZATION OF ORGANIC N-CHLORAMINES, K.F. Bowdring* and F. E. Scully, Jr., Dep't. of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508.

Organic N-chloramines are contaminants of chlorinated drinking water. However, until now no suitable method has been developed for their analysis in environmental systems. We have found that organic N-chloramines, generated by the reaction of their parent amine with tert-butyl hypochlorite or with commercial sodium hypochlorite, react rapidly with sodium benzenesulfinate to form benzenesulfonamide derivatives. The mechanism is probably S_N2 displacement of chloride from a nitrogen. The benzenesulfonamides have been characterized by their m.p., mixed m.p. with authentic samples, IR, and NMR.

Included in the compounds studied were primary and secondary amines as well as amino acids. Of these, the primary chloramines appear to be the least stable and the sulfonamides are produced in the lowest overall yields. The secondary chloramines as well as the N-chloroamino acid in general give higher yields.

The utility of this method for the identification and quantification of organic N-chloramines will be discussed.

MAGNETIC PROPERTIES OF STRUCTURE OF A POSSIBLE CYTOCHROME c OXIDASE MODEL, BIS(HEXAFLUOROACETYLACETONATO)(N,N'-ETHYLENEBIS[2-HYDROXYPROPIOPHENONEIMINATO-N,O(2-)]COPPER(II)) IRON(II), AND OF RELATED COMPOUNDS. Greg Brewer^a and EkkSim Dept. of Chemistry, Univ. of Va., Charlottesville, VA 22901.

The currently popular model of the active site of cytochrome c oxidase is a strongly magnetically coupled heme iron and a copper(II) species. We have synthesized and determined the structural and magnetic properties of a series of complexes which would then be models for the active site in reduced and oxidized forms of the enzyme. The linkage was chosen so as to allow maximum magnetic coupling. In every case, the magnetic coupling in our complexes is too small by an order of magnitude to match the literature magnetic data on the enzyme. These findings raise serious questions about the model, the literature data or both. High precision magnetic measurements are being carried out in our laboratory to reevaluate the literature results on the enzyme itself.

DIRECT OXIDATION OF PHENACETIN AND RELATED AMIDES TO THEIR HYDROXAMIC ACIDS. CRYSTAL STRUCTURES OF THE DIOXOMOLYBDENUM (VI) HYDROXAMATES DERIVED FROM PHENACETIN, ACETANILIDE AND BENZANILIDE. Greg Brewer^a and E. Sinn, Dept. of Chemistry, Univ. of Virginia, Charlottesville, VA 22901.

An oxidation method using diperoxo-oxohexamethylphosphoramide molybdenum(VI) has been adapted for the easy and direct conversion of phenacetin and related amides to their respective hydroxamic acids. The hydroxamic acids are the suspected toxic metabolites formed from analgesics like phenacetin and acetaminophen. Research on the metabolic pathway has previously been hampered by the difficulty in obtaining and storing the unstable hydroxamic acids. The hydroxamic acids are initially isolated as their stable dioxomolybdenum(VI) salts.

The Mo(VI) derivatives of two analgesics, phenacetin and acetanilide have been characterized by single crystal X-ray diffraction. The ligand environment about the Mo atom is a markedly distorted octahedron in each case, with the dioxo O atoms bonded cis to each other, while trans to these bonds the hydroxamate Mo-O bonds are elongated. There is no conjugation between the phenyl rings and the hydroxamic acid group.

CHARACTERIZATION OF SEVERAL FLAVANOLS ISOLATED FROM ANAPHALIS MARGARITACEA (Pearly Everlasting). Paula Bridwell^a and Samuel J. Gamble, Dept. of Chemistry, Lynchburg College, Lynchburg, Va. 24501

The flowers of *Anaphalis margaritacea* (pearly everlasting) were extracted in a Soxhlet extractor yielding flavanoid-like materials. Ethyl acetate was the solvent. Further separatory techniques with column chromatography gave four distinct compounds, each with relatively high melting points. Simple wet tests and spectrophotometric methods including NMR, IR, UV, and mass spectroscopy were used to help identify the compounds. Ashing of one of the samples revealed the presence of a metal. X-ray fluorescence was used as a confirmatory test.

Comparison of flavanoids from *Gnaphalium obtusifolium* (rabbit tobacco) is of interest from a taxonomic viewpoint.

THE VIBRATIONAL SPECTRA AND ASSIGNMENT OF DIMETHYLCHLORAMINE₂(CH₃)₂NCl. R. O. Carter and T. Hizer, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508.

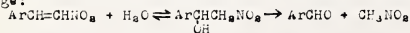
The infrared spectra of (CH₃)₂NCl from 4000-100cm⁻¹ will be presented. Both gas and solid phases have been investigated. Based on an assumed structure the A'' modes of this C_s molecule should have B-type band contours while the A' modes should display A-, C- or AC-type contours. Vibrational assignments have been made based on band contours and previous assignments for dimethylamine. Raman spectra have been recorded but are not very useful due to the formation of a polymer in laser beam.

The A'' methyl-torsion has been observed at ~260cm⁻¹. Based on an harmonic type model this results in a barrier of ~1400 cm⁻¹ which is closer to that found for trimethylamine than to that for dimethylamine.

pH AND SOLVENT DEPENDENCE OF THE KINETIC SOLVENT ISOTOPE EFFECT IN NITROSTYRENE HYDROLYSIS.

T. I. Crowell, Dept. of Chemistry, Univ. of Virginia, Charlottesville, Va. 22901.

β-Nitrostyrenes hydrolyze by adding water to form the nitroalcohol which then undergoes cleavage:



Acid-base catalysis of the hydrolysis has been studied in detail.¹

We now report that while the rate constant in H₂O is independent of pH from pH 0 to 4, in D₂O the rate descends to a minimum about pH 2-3. Here the solvent isotope effect, $k_{\text{H}_2\text{O}}/k_{\text{D}_2\text{O}}$ has the fairly large value of 6.5. This behavior is very similar to that of another system involving nucleophilic addition, the exchange of methyl borate with methanol.²

The rate constant for nitrostyrene hydrolysis at pH 2 is non-linear in the mole fraction of D₂O in H₂O-D₂O solutions.

References:

- (1) T. I. Crowell and T. R. Kim, *J. Am. Chem. Soc.* 95, 6781 (1973).
- (2) W. G. Hutton and T. I. Crowell, *ibid.*, 100, 6904 (1978).

STUDIES ON THE IDENTIFICATION OF AMINES IN

NATURAL WATERS. P. A. Drew^a, C. E. Bell, Jr. and F. E. Scully, Jr., Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508.

Despite the large amount of organic nitrogen in environmental systems few studies have identified amines in natural waters. In an effort to identify some of the labile nitrogenous by-products of water chlorination, we have begun a study aimed at identifying organic amines in pre-chlorinated water.

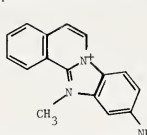
We have found that organic amines in concentrations of 100 ppb or less can be adsorbed from water samples by adjusting the pH of the water to 12 and passing it through a 30x65 mm column of Amberlite XAD-2 macroreticular resin. After removing excess water with dry nitrogen and equilibrating the resin with ether, the ether is filtered and concentrated. The concentrate is analyzed by gas chromatography. A local lake-water sample was analyzed in this fashion and found to contain organic compounds corresponding in retention time to suspected amines as well as neutral compounds. Methods and sample identification will be discussed.

THE INTERACTION OF HEAVY METALS WITH CHITOSAN. Catherine A. Eiden* and J. P. Wightman, Dept. of Chemistry, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

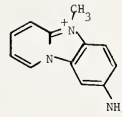
The interaction of the natural marine polymer chitin and its deacetylated derivative chitosan with lead and chromium has been investigated. The uptake of lead and chromium was determined from changes in concentration as measured by atomic absorption spectroscopy. A significant uptake of Pb(II) on both chitosan and chitin was observed. The uptake of Pb(II) on chitin was about 21% of that on chitosan. The number density of flakes observed in the scanning electron microscope and characterized by an intense Pb signal in EDAX was greater on the surface of chitosan than on chitin after equilibration with Pb(II) solution. The bonding state of lead on chitosan as determined by ESCA is similar to the bonding of lead in PbO based on the Pb 4f_{7/2} binding energy. A significant uptake of Cr(III) on chitosan was observed and a significant increase in the pH solutions of Cr(III) on equilibration with chitosan occurred. A high number density of nodules characterized by an intense Cr signal in EDAX was observed in chitosan with Cr(III) solution. [This research was done in part under the 1979 NSF-Undergraduate Research Participation Program at Virginia Tech, Dr. J. W. Viers, Director].

SYNTHESIS OF HETEROAROMATIC CATIONS. Richard J. Sundberg and James E. Ellis. Depart. of Chemistry, Univ. of Va., Charlottesville, Va. 22901.

Several classes of imidazolium derivatives have been synthesized for biological screening for activity against Chagas disease, a parasitic disease caused by the organism *Trypanosoma cruzi*. These compounds are modeled after intercalating agents, such as etidhim bromide and related cationic compounds, which are known to have activity against *T. cruzi* and related organisms. Methods for synthesis of selected imidazole, benzimidazole, imidazo[1,2-a]pyridine, pyrido[1,2-a]benzimidazole and benzimidazolinquinoline derivatives will be discussed. Additionally, methods for quaternization and introduction of side chains onto the heterocyclic rings will be covered. Typical examples are:



10-amino-12-methylbenzimidazo-
[2,1-a]isquinolinium



8-amino-1-methylpyrido-
[1,2-a]benzimidazolium

OSMOTIC COEFFICIENTS OF AQUEOUS SOLUTIONS OF ELECTROLYTES AT VERY HIGH DILUTION. Gerald M. Evans* and S. Y. Tyree. Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

The performance of a vapor pressure osmometer has been tested with aqueous solutions of sodium chloride (0.01-0.10 molal) and calcium chloride (0.0025-0.10 molal) as a means of measuring solvent activities at very high dilutions. The results prove the vapor pressure osmometer capable of use to obtain osmotic coefficients of aqueous electrolytes at concentrations 10-fold more dilute than is possible with the classical isopiestic vapor pressure apparatus.

5.8S rRNA METHYLASE ASSAY. Pamela E. Gallup and T. O. Sitz*. Dept. of Chemistry, Old Dominion Univ., Norfolk, Va. 23508.

Mammalian 5.8S rRNA, hydrogen-bonded to 28S rRNA in the 60S Ribosomal Subunit, has two 2'-O-methylated residues, Um at position 14, and Gm at position 77. Residue 77 is methylated in all 5.8S molecules, but the percentage of 5.8S molecules in which residue 14 is methylated varies according to cell type and position in cell. Residue 14 is methylated in less than 25% of 5.8S molecules from neoplastic cells, and in greater than 75% of 5.8S molecules from normal cells. Residue 14 is not methylated in 5.8S molecules located in nuclei, but is methylated in 5.8S cytoplasmic molecules. Preliminary *in vitro* studies with crude cell homogenates have not detected an increase in methylation when S-adenosyl-L-methionine is added. Studies are now being conducted using high-speed supernatants of Ehrlich ascites cell homogenates as the methylase source, and purified 28S-5.8S rRNA complex from Ehrlich ascites cells as the nucleic acid source.

"TWO DIMENSIONAL ELECTROPHORETIC STUDY OF HUMAN SEMINAL PLASMA PROTEINS", E. E. Gaunt and J. H. Yuan. Department of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508.

Human seminal plasma (HSP) is a complex fluid comparable to that of blood. As such, it can be of significant value in diagnosing biochemical abnormalities associated with male infertility. A technique capable of characterizing the protein constituents of seminal plasma is high resolution two dimensional (ISODALT) electrophoresis. This technique has been used successfully in the characterization of blood plasma and urine. (Anderson and Anderson, Proc. Natl. Acad. Sci., USA, Vol. 74, No. 12 (1977) and Clin. Chem. 25/7 (1979)). We have adapted this technique for use as a possible screening procedure in andrological studies.

HSP proteins are first separated by isoelectric focusing in a polyacrylamide disc gel with added ampholites. The first dimensional gel is then affixed to a SDS gradient slab gel to separate the proteins by size. Protein abnormalities arising from a change in a single amino acid residue are capable of being detected by this technique. Abnormalities have already been detected in a patient characterized as normal by cellular observation techniques.

FLUORESCENCE STUDIES OF THE DISSOCIATION OF CUCUMBER MOSAIC VIRUS. Ellen M. George and Sandra Boatman, Dept. of Chemistry, Hollins College, VA 24020

The binding of terbium ion(Tb³⁺) to single-stranded nucleic acid results in enhancement of the Tb³⁺ fluorescence. This paper describes preliminary experiments to determine whether this phenomenon can be used to study virus dissociation and assembly. Cucumber mosaic virus (CMV) consists of single-stranded RNA enclosed in a protein coat of 180 identical subunits. Excitation of intact CMV at 280nm gave an emission at 332nm while λ_{exc} of 295nm gave the same λ_{em} but 0.6 as intense. CMV dissociation by 0.01% sodium dodecyl sulfate (SDS) exhibited λ_{em} at 337nm 0.82 as intense as intact CMV with λ_{exc} of 280nm and the same λ_{em} with λ_{exc} of 295 nm(same intensity as intact CMV). Significant fluorescence enhancement occurs with pure CMV-RNA(4uM)at [Tb³⁺]₀ of about 0.1mM. Dissociation of virus with SDS or LiCl followed by addition of Tb³⁺ gave some enhancement of fluorescence over intact virus(1.5X), but less than expected. Reassembly of virus from the separated components was also studied. Addition to CMV-RNA of virus protein followed by Tb³⁺ resulted in less enhancement(0.50X) than shown by pure RNA (0.14 M NaCl in 0.01M Na Cacodylate pH 6.0). Addition to CMV-RNA of Tb³⁺ followed by protein resulted in somewhat greater enhancement(0.65X). NaCl caused slight quenching of the CMV-RNA-enhanced Tb³⁺fluorescence. The use of Tb³⁺ fluorescence enhancement shows promise as a technique for studying virus dissociation but requires more study.

THE ANALYSIS OF S-ADENOSYLMETHIONINE AND S-ADENOSYLMETHIONINE IN NORMAL AND MALIGNANT CELLS. K. E. Godburn and T. O. Sitz. Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508.

Altered patterns of methylation have been shown in both ribosomal and transfer RNA isolated from cancer cells. Hypomethylation appears as a general characteristic in contrast to the elevated activity of the methyltransferases responsible for the modification. One possible explanation for this paradox is that the concentrations of the substrate, S-adenosylmethionine, and the product, S-adenosylhomocysteine, are altered resulting in substrate inhibition or competitive product inhibition. It is important to correlate the concentration of these two compounds with the 2'-O methylation level of ribosomal RNA in various tissues. These levels can be determined using phosphocellulose liquid chromatograph or high voltage electrophoresis to obtain resolution and quantitative recovery of SAM and SAH from other components. Examination of the levels in a variety of tissue culture cells suggests that the concentration of these compounds is different in specific cell types. In addition the concentration of the compounds shows a relationship with the passage number of the tissue culture cells.

A STUDY OF THE REACTIONS OF VARIOUS RUTHENIUM BIPYRIDYL COMPLEXES. S. A. Hackney*, J. S. Hanner*, and F. A. Palocsay. Dept. of Chemistry, James Madison Univ., Harrisonburg, Va. 22807

$Ru^{II}(B)(Cl)_2(H_2O)$ has been found to catalyze the oxidation of ethanol to acetaldehyde. Oxidizing agents include oxygen and ferric chloride. Experimental data suggests that the Ru^{II} compound activates the alcohol by coordination, followed by an inner sphere oxidation-reduction reaction. Upon exposure to an oxidizing agent, acetaldehyde can be distilled from the reaction mixture.

THE ELUCIDATION OF THE STRUCTURE AND MECHANISM OF FORMATION OF 2,5-DI-T-BUTYL-1,4-BENZOQUINONE EPOXIDES. E. M. Hairfield and V. A. Stepp*. John Baker Daffin Lab. of Chemistry, Mary Baldwin Coll., Staunton, VA 25401

The alkaline peroxide epoxidation of 2,5-di-t-butyl-1,4-benzoquinone yields the *cis* and *trans* isomers of the diepoxide. Assignment of configuration to these isomers had been made on the basis of rather tenuous arguments based on chemical shifts, spin-spin coupling constants, and relative rates of hydrolysis. The previous workers had used mixtures of the isomers, as only 25 mg of the pure *cis* had been isolated by their method. We report the isolation of *cis* by fractional crystallization and we further show that the chiral *cis* isomer can be resolved, thus establishing its configuration in a totally unambiguous manner.

Studies have shown that alkaline peroxide epoxidations are first order each in clefin, peroxide, and hydroxide. Our studies confirm this general pattern for quinone epoxidation also. Furthermore, our studies show clearly that the reaction is sequential with $k_2 \ll k_1$, and the product distribution is determined by the E_a term of the Arrhenius equation rather than by ΔS^\ddagger . Implications of this are discussed, a mechanism is proposed, and directions for further study are outlined.

OPTICAL ANALOGUE OF CRYSTALS AND X-RAYS. Maureen M. Julian, Department of Chemistry, Hollins College, Va. 24020

This demonstration will optically mimic the history of the discovery of Bragg's law $h\lambda = 2d \sin \theta$ for which 24-year old William Lawrence Bragg won the Nobel prize in 1915. A mirror ball, of the type used in roller skating rinks, will represent the crystal; a beam of light will be the monochromatic X-ray beam; the light spots on the ceiling and walls will be the diffracted X-ray beams; the wall will be the film; and the room itself will be the camera. Both Laue's and X-ray powders will be demonstrated and actual X-ray photographs will be shown illustrating the remarkable similarity between the optical patterns generated on the wall and the patterns produced by real crystals diffracting X-rays.

DAME KATHLEEN LONSDALE, SCIENTIST IN ACTION. Maureen M. Julian, Dept. of Chemistry, Hollins College, Va. 24020.

Dame Kathleen Lonsdale, 1903-1971, a British chemist born in Newbridge, Ireland, was a lifelong investigator in the field of crystals and x-rays principally at the Royal Institution and later as Professor of Chemistry at University College London. In 1929 she solved the crystal structure of hexamethylbenzene, thus definitively proving that the benzene ring is flat. In recognition for her extensive work in diamonds, a mineral, lonsdaleite was named in her honor. Starting in 1962, she did research on the chemistry of bladder, kidney, and gall stones. A convert to Quakerism, she wrote and lectured extensively on the problems of peace, freedom, and justice. As a pacifist she went to jail for a month during World War II and afterwards took up the cause of penal reform. Her fright and depression about atomic weapons is reflected in her monograph, *Is Peace Possible?* She traveled widely, wrote, in addition to over 200 scientific papers, a text *Crystals and X-rays*, and edited the *International X-ray Tables*. In 1945 she became the first woman elected as a Fellow of the Royal Society. In 1956 she was knighted and, as a climax to her career, in 1968 she became the first woman president of the British Association for the Advancement of Science.

TRACE AMINE ANALYSIS: CORRELATION STUDIES OF BIOGENIC AMINES USING HIGH PERFORMANCE LIQUID CHROMATOGRAPHY. Thais Keegan and R. L. Williams, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508.

Reverse phase HPLC, in which retention is a function of hydrophobic interactions between solute molecules and the stationary phase, is an increasingly popular method for single-run analysis of mixtures. The μ -Bondapak phenyl column (Waters Associates, Milford, Mass.) is preferable for biogenic amines, especially catechol compounds, to octadecyl silica (C₁₈).

Pre-column derivatization of primary amines with o-phthalaldehyde and mercaptoethanol yields a highly fluorescent, stable lactim adduct capable of interaction with the column packing. The method, therefore, is applicable to both alkyl and aryl amines at picomole levels in biological material.

Retention of the adduct relative to an internal standard adduct of 3,4-dihydroxybenzylamine can be correlated to the structure of the primary amine.

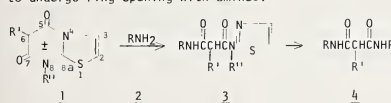
Within-run mobile phase variation allows separation and analysis of the complex mixture of primary amines, especially those in the biosynthesis and metabolism of catecholamines.

STUDIES ON NIOBIUM HETEROLIGAND PEROXO COMPLEXES. K. G. Lloyd* and G. Djordjevic, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185.

Heteroligand peroxo complexes of Nb(V) are derived from tetra-peroxoniobate by substituting one, two, or three peroxo groups with mono- or polydentate ligands. The syntheses are strongly pH dependent. Polycarboxylate ions have previously been found to form crystalline and stable peroxo complexes with niobium, and to continue these studies, substitution with glycine, α -alanine and proline, respectively, has been attempted. White, insoluble, X-ray amorphous substances were obtained. They are stable in air, but decompose by gradually losing peroxide on prolonged standing or heating. The Nb/O₂²⁻ ratio of 1/1 was found in several repeated preparations. The i.r. spectra of peroxo derivatives with all the three amino acids are similar. Absorption occurring in the region 3400, 1640, 860, and 700-460 cm⁻¹ is poorly resolved. Nevertheless, the range between 890-950 cm⁻¹ is transparent and a niobyl stretching band, characteristic for a terminal Nb=O group, is absent. The peroxo stretching occurs at 860 cm⁻¹. Strong, complex absorption covering the wide range of 700-460 cm⁻¹ indicates the presence of Nb-O-Nb bridging vibrational modes. According to analytical and spectral evidence these peroxo aminoacetato niobium complexes are polymeric, corresponding to the formula [NbO(O₂)L]_n, L = α -amino acid, and μ -oxo bridging, common in niobium complexes, is present.

PRELIMINARY RING-OPENING STUDIES OF MESOIONIC PYRINONES, G.O. Hsuegwu, A.G. Bass and R.A. Glennon, Depts. of Chem. and Pharm. Chem., Virginia Commonwealth Univ., Richmond, Va. 23284.

Mesonic thiazolo[3,2-a]pyrimidin-5,7-diones **1** are known to undergo ring-opening with amines.



The ability of these compounds to function as acylating agents, may account for their in vitro biological activity. The mesonic compounds **1**, (R¹=H, CH₃, CH₃CH₂; R²=CH₃CH₂, (CH₃)₂CH, (CH₃)₃C) in refluxing tetrahydrofuran give a high yield of the ring-opened product **3**. When R¹=CH₃, CH₃CH₂; R²=CH₃CH₂, the mesonic compound does not react with benzylamine in refluxing THF or dioxane. Reacting **1** (R¹=R²=CH₃CH₂) in refluxing phenethyl amine gives rise to **4**. Preliminary kinetic studies of the reaction of phenethylamine and **1** (R¹=H, R²=CH₃CH₂) in THF at 66°C indicate a second-order rate constant of 8.3 lit mole⁻¹ sec⁻¹.

This work was supported in part by the U.S. Public Health Service Grant No. HL22566.

PREPARATION OF C-SUBSTITUTED DERIVATIVES OF 1,2,3-(η^5 -C₅H₅)CoC₂B₉H₇ BY THE REACTION OF 2-(η^5 -C₅H₅)CoB₉H₇ WITH SUBSTITUTED ALKYNES. V.R. Miller and C.C. Corcoran*, Dept. of Chemistry, Roanoke Col., Salem, Va. 24153

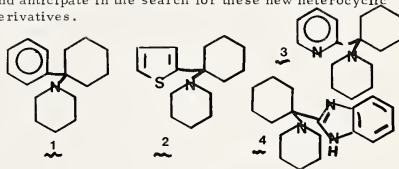
As in gas phase reactions, 2-(η^5 -C₅H₅)CoB₉H₇ will react with substituted acetylenes in solution to yield C-substituted derivatives of 1,2,3-(η^5 -C₅H₅)CoC₂B₉H₇. Thus, the reaction at 100°C of phenylacetylene with C₆H₅CoB₉H₇ for 24 hrs. in decane under nitrogen gave 1,2,3-(η^5 -C₅H₅)Co(C₆H₅)C₂B₉H₇. In a similar manner 1,7-octadiene reacted to give 1,2,3-(η^5 -C₅H₅)Co(HC(CH₃)₂)₂C₂B₉H₇ and diphenylacetylene reacted to give 1,2,3-(η^5 -C₅H₅)Co(C₆H₅)₂C₂B₉H₇. The latter compound was not stable at this temperature and reacted further to give C,C'-disubstituted 1,7-(η^5 -C₅H₅)₂Co(C₆H₅)₂C₂B₉H₇ and other, unidentified products. There was no evidence for the addition product found by Grimes et al. in the corresponding gas phase reaction. (Supported by a Research Corporation Cottrell College Science Grant. Appreciation to Univ. of Virginia, Dept. of Chemistry for assistance in obtaining spectra.)

ESTIMATION OF THE PROTONATION CONSTANTS OF WEAK BASES BY SIMPLEX OPTIMIZATION. J. G. Mason and H. Bell, Dept. of Chemistry, VPI & SU, Blacksburg, Va. 24061

A modified simplex optimization program has been developed for the determination of equivalence points, calibration of the glass electrode, and estimation of the pK_a from titration curves for weak bases. Both monoprotic and diprotic systems will be discussed. Data obtained yield reliable pK_a values in spite of fluctuations in electrode calibration.

PYRIDINE ANALOGS OF PHENCYCLIDINE. J. McKenney and R. L. Williams, Dept. of Chemical Sciences, Old Dominion University, Norfolk, VA. 23508.

Phencyclidine **1** (PCP) has established itself over the past ten years as a drug of abuse and considerable research has been conducted into its mechanism of action and structure-activity studies. An examination of the recent literature related to the various analogs of PCP has shown that the only heterocyclic analog reported to date in the thiophene derivative TCP **2**. This laboratory has undertaken a synthetic program to synthesize a variety of heterocyclic analogs including the pyridine and benzimidazole structures **3** and **4**. This paper will discuss the various synthetic routes we have attempted and anticipate in the search for these new heterocyclic derivatives.



C-13 NMR OF METAL-FREE AND METAL-SUBSTITUTED CARBONIC ANHYDRASE. P.J. Morley* and R.C. Khalifah*, Dept. of Chemistry, Univ. of Va., Charlottesville, Va. 22901

Carbon-13 NMR in conjunction with selective isotopic enrichment has been used to study the effects of removal of the intrinsic zinc from the active-site of human erythrocyte carbonic anhydrase. His-200 was carboxymethylated using 90% 1-¹³C bromoacetate which introduced a "probe" into the active site. The resonance of the enriched carboxylate is easily detected and was previously shown to be sensitive to changes of pH and inhibitor binding in the zinc enzyme. Data on the zinc carboxymethyl enzyme gave evidence for a zinc-carboxylate coordination. Most recently derivatives of the enzyme were prepared by removal of the zinc, and the enzyme was reconstituted with metals such as Co²⁺, Cd²⁺ (including ¹¹³Cd²⁺) and Hg²⁺ (including ¹⁹⁹Hg²⁺). The possible interaction of these metals with the introduced carboxylate has been investigated. Using chemical shift studies, 2-bond coupling techniques and spin-lattice relaxation times, this interaction has been ruled out in the inactive Cd²⁺ and Hg²⁺ derivatives as well as inhibitor complexes of the enzyme.

Chemical shift behavior of the enriched carboxylate resonance has permitted determination of the pK_a of the imidazole ring of carboxymethylated-His-200 in various metalloderivatives in the presence and absence (usually) of inhibitors indicating dramatic changes of its properties.

(Supported by USPHS Grant).

THE METHOD OF PSEUDOPOTENTIALS. Eileen O'Brien*, J. C. Schug and G. Sanzone, Dept. of Chemistry, VPI & SU, Blacksburg, VA 24061.

Pseudopotential theory[1] suggests a valid and simplified valence-electron approach to electronic structure calculations of atoms and molecules. The effective replacement of the core electrons of an atom by a pseudopotential is discussed, and the properties of a pseudopotential are deduced from its explicit functional form. Various workers[2] have generated *ab-initio* pseudopotentials for atoms located as far down as the 5th row of the periodic table. Hartree-Fock molecular calculations over large but "coreless" atomic systems are now tractable, since the total number of electrons to consider is just the number of valence electrons contributed from each atom. Recent *ab-initio* calculations incorporating the prescribed pseudopotentials[3] have been performed on Hg and Hg₂. The results of these calculations are presented.

- [1] J. C. Phillips and L. Kleinman, Phys. Rev. **116**, 287, (1959).
- [2] L. R. Kahn, P. Baybutt and D. G. Truhlar, J. Chem. Phys. **65**, 3826, (1976); S. Topiol, Ph.D. Thesis, (N.Y. Univ., N.Y., 1976).
- [3] P. J. Hay, W. R. Wodt, L. R. Kahn and F. W. Bobrowicz, J. Chem. Phys. **69**, 984, (1978).

ELECTRON IMPACT STUDIES OF ARGON DIMERS. Edward F. Rickman* and G. Sanzone, Dept. of Chemistry, VPI & SU, Blacksburg, VA 24061.

Van der Waals diatomic molecules of rare gases have been formed in pulsed free jet expansions with a nozzle-beam apparatus. Direct ionization and excitation of these species can be studied in crossed electron-beam/molecular beam experiments which employ mass spectrometric and fluorescence detection. In this paper, the design and fabrication of an electron beam is described for the determination of ionization potentials of rare-gas diatomics by the RPD method. The RPD method for molecular beam studies is discussed along with the possible ion species detected. Attention is then focussed on the species Ar₂⁺.

STUDIES OF THE STRUCTURES PRODUCED BY RADIATION DAMAGE TO DNA. Karl A. Schellenberg and James Shaeffer, Department of Biochemistry and Department of Radiation Oncology and Biophysics, Eastern Virginia Medical School, Norfolk, VA. 23501.

The irradiation of aqueous solutions of native calf thymus DNA with x-rays produced borohydride reactive sites. The sites were labeled with tritium by reacting the DNA with NaB³H₄ in NH₄Cl buffer, and the labeled DNA was precipitated with trichloroacetic acid, collected on a glass fiber filter, and assayed for tritium and ultraviolet absorption. The DNA incorporated tritium to the extent of about 2.0 x 10⁻¹⁰ atom ³H/dalton/rad. The tritium-containing moiety, presumably an altered deoxyribose residue at the strand end, was relatively stable to dilute alkali. Hydrolysis of the labeled DNA in 6M HCl for 6 h at 120° gave 4 tritium-labeled products as determined by thin layer chromatography. The four products appeared identical with those obtained from DNA damaged by chemically generated hydroxyl radicals, and two of the products appeared identical with products obtained by hydroxyl radical reaction with deoxyadenosine or thymidine. Possible structures of these products will be discussed.

POLYCARBOXYLIC ACID POLYMERS AS ANTITUMOR AGENTS. Raphael M. Ottenbrite, Department of Chemistry, Virginia Commonwealth University, Richmond, VA 23284.

Anionic polymers have been shown to be excellent immunopotentiators and do inhibit tumor growth. Like most other agents in this class, they possess certain toxicities that limit their usefulness. However, our studies indicate that the toxicologic actions of pyran, for example, are a function of high molecular weight species which are not necessary for therapeutic activity. By preparing new anions and using separation techniques it appears that polyanionic anti-neoplastic immunopotentiators can be prepared which are devoid of adverse clinical limiting effects. Additionally, identification of the molecular weight species essential for this activity may stimulate research into the host receptor responsible for the antitumor activity.

The copolymers were characterized through NMR, elemental analysis, titrations, and viscosity. Biological evaluations carried out include; antiviral activity against encephalomyocarditis (EMC) virus, antineoplastic activity against Lewis lung carcinoma and Friend leukemia, activations of macrophage, effect on microsomal enzymes as indicated by the prolongation of hexobarbital sleeping time and an evaluation of hepatosplenomegaly.

ANALYSIS OF DIPOLE MOMENTS FOR BINARY MOLECULES USING A POINT-CHARGE COULOMBIC MODEL. L. J. Sacks, Christopher Newport College, Newport News, VA 23606

The dipole moments of binary hydrides are assessed using a point-charge model in which four pairs of electrons are arranged around the core of the central atom, one or more of these containing a proton, and the assemblage treated according to the molecular symmetry (C_{nv}). The E-H distance is used to establish the contribution of the hydride ion to the molecular dipole and then the angles and distances to the center of charge for the line pairs are considered in light of both qualitative expectation, using minimum repulsion considerations, and quantitative calculations of the two-parameter systems. In the cases of ammonia and phosphine, unique solutions result, and these are used as reference situations for other molecules. The concept of "bond dipole" is reconsidered in light of the charge distributions needed to accommodate the "partial ionic character" of molecules such as HCl and the so-called "covalent" bond which would have zero dipole moment. The description of the wave function embodying these postulated models is compared with that for the point charge model.

STUDIES ON THE DECOMPOSITION OF N-CHLOROPIPERIDINE IN AN AQUEOUS MEDIUM. J. Schlager* and F. E. Scully, Jr., Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508.

Organic N-chloramines are understudied components of chlorinated water. Little is known of their lifetime or stability in an aqueous medium. Because N-chloropiperidine (NCP) is a strongly suspected contaminant of chlorinated water, the stability of NCP in aqueous buffered solutions was examined at 25° in 0.1M potassium phosphate and 0.4M NaCl at pH's of 1.0 to 9.0. The first order decay rate is constant over the pH range 3.0 to 9.0 and the calculated half-life is about 7 days. At pH's lower than 3.0 the decay rate increases dramatically as the solution becomes more acidic. A mechanism and possible products will be discussed.

A study of the model metabolism of NCP has also been undertaken. In the presence of the Udenfriend model metabolism system NCP is converted largely to piperidine along with other minor products. The health implications of these data will be discussed.

THE REDOX CHEMISTRY OF URANIUM IN MOLTEN SILICATES. Henry D. Schreiber and Stephen M. Andrews, Dept. of Chemistry, VMI, Lexington, VA 24450.

An understanding of the oxidation-reduction chemistry of uranium in molten silicates has direct application to problems in nuclear waste disposal, geochemistry, and glass manufacture. The uranium redox equilibrium in Ca-Mg-Al-silicate melts has been determined as a function of the base composition, melt temperature, imposed oxygen fugacity, and total uranium content. Evidence of a U(VI)-(V)-U(IV) equilibrium in the molten silicates has been established. The equilibrium is relatively insensitive to melt temperature and total uranium content, but is quite dependent on the base composition and imposed oxygen fugacity. Through comparisons with previous studies of other redox couples in analogous melts, uranium has been placed in a reduction potential series for a silicate melt as a solvent; in order of ease of reduction, Ce(IV)-Ce(III) > U(VI)-U(V) > Fe(III)-Fe(II) > U(V)-U(IV) > Cr(III)-Cr(II) > Eu(III)-Eu(II) >> Ti(IV)-Ti(III).

THE FIRST SPIN STATE EQUILIBRIUM IN ANY d^4 COMPLEX; AN ALTERNATIVE CYTOCHROME c OXIDASE MODEL. MAGNETIC PROPERTIES AND CRYSTAL STRUCTURE OF $\text{Tris}[\text{1-(2-AZOYL)-2-AZABUTEN-4-YL}]\text{AMINEMANGANESE(III)}$. Greig Sim# and Ekk Sinn, Dept. of Chemistry, Univ. of Va., Charlottesville, VA 22901.

An equilibrium is theoretically possible between the high spin and low spin states of d^4 complexes, but this has never been observed. This is the only d^4 configuration for which a theoretically possible equilibrium could not so far be experimentally verified. The title complex has this spin equilibrium and its magnetic, structural and spectral properties will be reported.

The currently popular model for the active site in the oxidized form of cytochrome c oxidase involves a strong magnetic coupling between Fe(III) and Cu(II) atoms. This model could well be wrong, and the literature magnetic data for the enzyme could be explained as well by an Fe(IV) heme center (quite possible for porphyrin derivatives) and an inactive Cu(II) center. The Fe(IV) would have to exhibit a spin equilibrium to match the literature data. Fe(IV) has configuration d^4 , for which a spin equilibrium is theoretically possible and has now been experimentally verified.

TRACE METALS IN RAINWATER. Pamela T. Simpson* and Neal G. Sumerlin, Chemistry Dept., Lynchburg Col. Lynchburg, Va. 24501

The concentrations of several trace metals in rainwater samples collected over a 6-month period have been measured by atomic absorption spectrometry. The trace metals were first concentrated by diethyldithiocarbamate chelating agent, then extracted with methyl isobutyl ketone. Using this method, parts-per-billion levels of trace metals have been detected.

The highest levels seem to be in small, pre-summably dirty, rainfalls. Further testing is contemplated to determine the amount coming from solid material suspended in the rain, and to follow concentration changes within a single rain.

ELECTRON PAIRING EFFECTS AND THEIR RELATION TO STRUCTURE IN SOME NICKEL(II), COBALT(III), AND COPPER(II) COMPLEXES.

T. Thanayasiri* and Ekk Sinn, Department of Chemistry, Univ. of Va., Charlottesville, VA 22901.

Pairing and unpairing of electrons in mononuclear d^6 and d^8 and in binuclear Cu(II) complexes have been investigated in order to relate structures to their magnetic properties. For d^6 system, a second known Co(III) complex, exhibits spin state crossover proven by temperature dependent magnetic measurements, was prepared. In the Ni(II), d^8 complexes $[\text{Ni}(\text{L})_2\text{X}]$, where L = some substituted thioureas and X = Cl or Br, we found that their temperature dependent magnetic moments are due to effects of two different phenomena, not just an effect of spin crossover alone. Structural features influencing ferro- and anti-ferromagnetic interactions in binuclear Cu(II) complexes were studied by designing compounds in which the two interactions are in balance. $[\text{Cu}(\text{dien})\text{Cl}_2(\text{NO}_3)_2]$ is an example of such compounds.

MODELLING COMPLEX CHEMICAL SYSTEMS WITH THE MICHIGAN EXPERIMENTAL SIMULATION SYSTEM: CHEMICAL SWITCHES AND OSCILLATIONS. Don Thomason and Carl Trindle, Dept. of Chemistry, University of Virginia, Charlottesville, VA, 22903.

Chemical oscillations occur under non-equilibrium conditions. Most mechanistic schemes for chemical oscillators have an autocatalytic step, creating instability. The nonlinear autocatalytic step leads to a possibility of multiple steady states. Both temporal and spatial structure may develop in the course of the reaction. We have examined the glycolysis oscillator experimentally and with the aid of the Michigan Experimental Simulation system, and established that the oscillations in this system agreed in phase only in small regions characterized by a critical length of ca. 0.025 cm, producing locally ordered structures. Similar local order would have been required to generate structure - and eventually life - from the "primordial soup".

THE SYNTHESIS AND REACTIVITY OF MOLYBDENUM COORDINATION COMPLEXES. Joseph Topich, Department of Chemistry, Virginia Commonwealth Univ., Richmond, Virginia 23284

Molybdenum is an unusual transition element in that it can exist in oxidation states +6 to -2. This versatility makes molybdenum an attractive candidate for several redox enzymes, most notable is nitrogenase. We report here on monomeric molybdenum coordination complexes that serve as potential molybdoenzyme models. Cis-dioxomolybdenum(VI) complexes incorporating tridentate Schiff base ligands have been synthesized and characterized. Cathodic reduction potentials are controlled by subtle ligand modifications. Molybdenum complexes have also been covalently attached to insoluble polystyrene to block molybdenum(V) dimer formation. EPR data will be presented and the reaction chemistry of these complexes with nitrate and triphenylphosphine will be discussed.

STUDIES ON THIOUREA COMPLEXES OF LINEAR POLYARYLS.

Ann Tyree* and James B. Patrick, John Baker Daffin Lab. of Chemistry, Mary Baldwin Coll., Staunton, Virginia 24401
Canal-type inclusion complexes of thiourea and methyl-branched aliphatic hydrocarbons are well known, but there are a few cases such as *p*-di-*tert*-, butylbenzene which suggest that complexes of some aromatics are possible. Models also support this speculation. Analogy with the aliphatic cases indicates that the ratio thiourea:hydrocarbon should increase as the aromatic substrate molecules increase in length.

We have studied the reaction, under conditions for complex formation, of thiourea with biphenyl, *p*-terphenyl, *p*, *p'*-di-*tert*-, butylbiphenyl, and *p*, *p'*-di-*tert*-, butyl-*p*-terphenyl. Crystalline substances containing both thiourea and hydrocarbon were obtained in all cases, but the ratio of thiourea to hydrocarbon was less than 1 with the three cases where no *tert*-, butyl groups were present; these 3, therefore, can not be inclusion compounds. The ratio of thiourea:hydrocarbon was greater than 1 for the three *tert*-, butylated hydrocarbons, but it was small and decreased with increasing length of the guest molecule. It seems doubtful, therefore, if any of these substances are true canal inclusion compounds. However, if they are not, the models require reinterpretation and the case of *p*-di-*tert*-, butylbenzene, which has hitherto been accepted in the literature as a true inclusion compound, is called into question.

STUDIES ON VANADIUM HETEROLIGAND PEROXO COMPLEXES. P. L. Wilkins* and C. Djordjevic, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185.

Heteroligand peroxo complexes of V(V) can be derived from a variety of existing peroxo and oxoperoxo vanadium species. To be distinguished from niobium, vanadium complexes separated from acid or neutral solutions invariably possess terminal or bridging oxo groups. We have investigated preparation of peroxo polycarboxylato and aminocarboxylato vanadates, analogous to compounds characterized previously for niobium. Crystalline ammonium and potassium salts of peroxo vanadates containing nitrilotriacetato and iminodiacetato ligands were obtained. They contain two peroxo groups and a polycarboxylato ligand per metal ion, and the i.r. spectra show characteristic strong bands in the 960-840 cm^{-1} region. The compounds are stable at room temperature and do not lose peroxide on prolonged standing. Attempts to prepare peroxo- α -aminoacetato vanadates, as obtained for niobium, were not successful. Chemistry of these heteroligand peroxo vanadates seems to have little in common with the chemistry of peroxo niobates. Redox behavior of coordinated peroxo group in various complexes was investigated in aqueous solutions. It was observed that in certain ligand spheres superoxide intermediate is formed. The potential of peroxide oxidation via $\text{O}_2^{2-} \rightarrow \text{O}_2 \rightarrow \text{O}_2$ will be discussed.

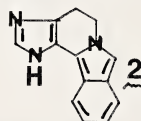
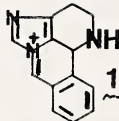
ION CHROMATOGRAPHY: INTERFERENCE OF CHLORIDE IN SULFATE DETERMINATION. William E. Weiser* and S. Y. Tyree. Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

A study was conducted of the effect of large variations in chloride ion concentration upon the determination of sulfate ion in the 0-100 ppm range. The solutions studied contained only sodium chloride and sodium sulfate, using a Dionex Model 14 Ion Chromatograph. Up to 4000 ppm chloride the sulfate peak is independent of the amount of chloride present. Above 4000 ppm chloride the sulfate peak is affected by variations in chloride concentration.

CONDENSATION PRODUCTS OF HISTAMINE AND ORTHOPHTHALDEHYDE. R. L. Williams and Bev Renfrow, Dep't. of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508.

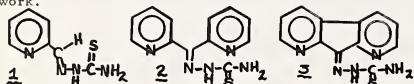
The condensation of histamine with orthophthaldehyde (OPT) was first described by Shore *et al.* in 1959. This reaction was initially found to give rise to a fluorescent product, and this reaction has been used as a means of assaying for histamine in biological samples for some years. The structure proposed for this product is shown below, 1.

We have recently re-examined this reaction and the nature of the fluorescent product and wish to present synthetic and spectral data which suggest that the product is actually the isoindolol (2). This structure is currently under further investigation as in the reaction OPT with other biogenic amines.



POTENTIAL ANTITUMOR AGENTS: 2,2'-BIPYRIDYL THIOSEMICARBAZONES AND THEIR METAL COMPLEXES. R. L. Williams, L. Wolfenbarger and A. Principe*. Dep'ts. of Chemical Sciences and Biological Sciences, Old Dominion Univ., Norfolk, VA. 23508.

α -Heterocyclic thiosemicarbazones such as 1 have been shown to be effective antitumor agents against a variety of tumor lines. We wish to describe our continued research in the synthesis and evaluation of a series of 2,2'-bipyridyl thiosemicarbazones 2 and 1,8'-diazafuonanthiosemicarbazones 3. These compounds together with the iron and copper complexes of 2 have been shown to be active against Ehrlich Ascites tumor cells in mice. These findings have now been supported by recent studies which indicate that both the ligand 2 and its metal complexes are effective inhibitors of the target enzyme, ribonucleotide reductase. This paper will describe the most recent results from the *in vitro* studies with these compounds and proposals for future work.



ISOLATION OF AN ACTIVE, COPPER-CONTAINING FRAGMENT OF HUMAN SERUM FERROXIDASE-II. James H. Woodruff and Richard W. Topham, Dept. of Chemistry, University of Richmond, Va. 23173.

Ferroxidase-II is a large and structurally complex enzyme of human serum that has been proposed to facilitate the mobilization of iron from storage tissue by promoting the oxidation and incorporation of iron into the serum transport protein, transferrin. It possesses protein-bound lipid and copper components which are essential for the maintenance of its catalytic activity. An enzymically active, low molecular weight fragment of ferroxidase-II has been generated by proteolytic cleavage with chymotrypsin. The active fragment was purified by gel-filtration and ion-exchange chromatography. The purified fragment possesses high concentrations of bound copper and lipid components, both of which are essential for the maintenance of its activity. Furthermore, the fragment is kinetically similar to native ferroxidase-II. This fragment appears to constitute the active site(s) of ferroxidase-II. Detailed structural studies of this fragment should provide considerable insight into the nature of the active site of this physiologically important enzyme. (Supported by USPHS, NIH Grant 2-R01-AM 20148-03 and a faculty research grant from the Univ. of Richmond).

STUDIES OF NAD GLYCOHYDROLASE ISOZYMES FROM BULL SEMEN. S. D. Yeatts and J. H. Yuan. Dep't. of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508.

NAD glycohydrolase (NADase), capable of catalyzing the hydrolysis of the nicotinamide N-ribosidic linkage of NAD, was purified previously by conventional procedure (J. Biol. Chem., 246:2111, 1971). In search for a simple, rapid procedure for the preparation of this enzyme, it was found that Matrex Red A (Amicon) gel served very well as an affinity gel for NADase. The enzyme was found to the Matrex Red A affinity column in 10 M sodium phosphate buffer, pH 6.0, and two fractions of NADase activity were obtained when the column was eluted with a linear gradient of NaCl from 0-2.5 M. NADase I and II were eluted at a NaCl gradient at 0.25 M and 1.20 M respectively.

Molecular weight of NADase I and II were estimated to be about 60,000, and this indicates that both of these isozymes exist in a dimeric form. Most surprisingly, both NADase I and II were found to catalyze a pyridine base exchange reaction which has not been reported before. Details of the kinetic and pyridine base exchange studies will be described.

Education

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

USING COMPUTERS IN SCIENCE INSTRUCTION: WAYS AND MEANS.
James D. Beck, Dept. of Chemistry, Virginia State Univ.,
Petersburg, VA 23803

Although the number of high schools and colleges which have access to computers for instructional use has increased dramatically over the past few years, their impact on science instruction has been very slight. Is it time for the computer to play an important role in the science classroom? Or are we still waiting for the computer revolution to reach the field of education?

Most of the arguments which science teachers have used to justify their ignoring the computer as an instructional tool are no longer valid. Inexpensive microcomputers are becoming popular everywhere (even in schools!), and the amount of computer-based learning materials is increasing rapidly. And one does not need to become a computer programmer in order to utilize the computer in the classroom. Books and college courses on computer-based instruction can illustrate the ways in which the computer can be used and the advantages to be gained by using it.

Your students can benefit from computer-based experiences--tutorials, problem-solving work, drill-and-practice exercises, simulations, graphics demonstrations, computer-generated problem sets, etc. Beg, borrow, or buy a microcomputer or live terminal. Get some programs in your field. Try them. Let some of your students try them. See if you don't agree that the computer can excite and enlighten your students and rejuvenate your teaching.

BREADTH, DEPTH, AND MOUNTAIN PEAKS: COMPLETING THE LEARNING CYCLE. Michael L. Bentley, Supervisor of Science, Va. Dept. of Education, Richmond, Va. 23216

Fiscal restraint and 'back-to-the-basics' have endangered special activities for children, such as field trips. Recent educational and neuroscience research supports the value of such experiences for cognitive growth. The potential of field experiences for learning may be more pronounced at certain ages. Children at different developmental levels respond in different ways to site characteristics. Field activities can be structured to maximize meaningful interaction between learner and environment. Efforts to evaluate "peak" experiences must take account of long term effects which act in areas of the learning cycle often ignored in educational practice. The Va. Dept. of Education's Project OUTSIDE is developing field site guides for the seven regions of Virginia. These guides will provide teachers with background information about the site and will be designed for learner inquiry.

COMMUNITY BASED PROGRAM FOR GIFTED SCIENCE STUDENTS.

Mariana R. Becker, and Jeane J. Dughi, Science Division,
Department of Instruction, Norfolk Public Schools, Norfolk,
VA, 23510

The Norfolk Public Schools secondary gifted program is designed to provide the student with research skills, an opportunity to utilize these skills through scientific investigations and participation in scientifically oriented community resources such as Eastern Virginia Medical School, NASA at Langley Air Force Base, and local Universities.

ISIS and the NDN. R.N. Giese. Sch. of Educ., Col. of William and Mary.

In 1977-78 the effectiveness, for nonscience prone secondary students, of the 34 commercially available minicourses in the Individualized Science Instructional System was tested. The testing program involved 33 teachers and 1468 (nonscience major) secondary students in 7 states. Each teacher selected 6 minicourses (about 400) were put into a pool and randomly distributed in test packets containing about 35 items. Each student was given the same test as a pre & post test.

Each nonscience prone student using the ISIS program completed 4 or 5 minicourses each semester. All other students in the participating schools were science prone and taking traditional science courses. Thus the control group for each minicourse was made up of the students using ISIS but who had not done that particular minicourse.

The reliability of the tests were found to be between .72 & .90 (KR20). The pre & post test scores for each minicourse were found to be significantly (at the .05 level) different. For each minicourse the pre & post test score was 45% or below and the post test score was 60% or above.

Based on such data ISIS was approved by the Joint Dissemination Review Panel for inclusion in the National Diffusion Network.

In Va. this means that local school systems can write a proposal for adopter/adaptor grants & receive federal funds to cover the cost of securing the project's materials, teacher training, and evaluation.

THE DORM EFFECT AND ATTAINMENT OF THE BACCALAUREATE DEGREE. Bernard H. Levin, Blue Ridge Cmty. Col., Weyers Cave, VA 24486, and Darrel A. Clowes, Virginia Tech, Blacksburg, VA 24061.

This study examines data from the National Longitudinal Study of the High School Class of 1972 to test the relationship between residential status of full-time students and receipt of a four-year degree within four years of high school graduation. Such degrees were obtained by 55% of those initially attending a four-year college and living with their parents, and by 66% of those initially attending a four-year college and living in a dormitory or college apartment ($N = 597$, CHI Squared = 6.13, $p < .02$). Available data on student characteristics did not provide alternative explanation; the NLS data unambiguously establish a "dorm effect."

BLOCK SCHEDULING: CRISES IN ENROLLMENT AND ENERGY DEMAND A NEW APPROACH FROM VIRGINIA'S COLLEGES AND UNIVERSITIES James P. B. O'Brien, Division of Social Sciences, Tidewater Community College, Virginia Beach, Va., 23456

Throughout Virginia and the nation, evening college classes are regularly taught in 3-hour blocks. Students are attracted to evening classes because they can reach educational and career goals and at the same time meet their needs for employment, child care, and the most efficient allocation of temporal and financial resources. As the complexion of the work force changes (more women, more older workers, more needs for skills acquisition or refinement), as the traditional population of educational consumers wanes, as transportation becomes more expensive, and as jobs and services scheduling becomes more innovative (flextime, 4-day weeks, 5 and 4-bimonthly variations); institutions offering educational services, especially those with substantial commuter populations, will remain attractive only to the degree that they are responsive to the changes and pressures facing potential students. A tried and successful method, namely: 3-hour block scheduling, should be made available during daytime sessions to enable students to use educational resources most efficiently. The benefits to a state that has substantial tourist and leisure industries dependent on personal transportation are also noteworthy.

TEACHING STATISTICS TO SECONDARY SCHOOL STUDENTS A NOVEL APPROACH. H. W. Straley. Dept. of Math, Woodberry Forest Sch, Woodberry Forest, VA. 22989

The most important reason many high school students continue to study mathematics is their perception of its usefulness in their futures. Inferential statistics is an area of mathematics that can be taught to students who have only an elementary algebra background. It is also an area of mathematics for which real world applications are easily understood by pre-college students. Inferential statistics may be the only area of mathematics that meets both of the above conditions.

This paper describes an innovative six week unit on inferential statistics that has been successfully taught to Algebra II students. The unit has also been expanded into a term course without increasing teacher loads. The term course expands upon the statistics content by providing an opportunity for students to write and orally present a statistically oriented research paper.

In addition to describing course content and organization the author presents sample test items and provides data on student achievement. Some student papers are available and some preliminary research data on the attitudinal effects of the statistics unit are presented.

THE PROBLEM THAT WON'T GO AWAY. W. A. Moyer, National Association of Biology Teachers, Reston, VA 22090.

The creationist doctrinal position includes belief in absolute integrity of Holy Scripture, the Triune God, direct creation of all things, man created in God's image, and the biblical framework of history. Problems arise when students with such belief structure encounter science courses. Wendall Bird, a creationist lawyer, argues that teaching evolution solely denies free exercise of religion for such students, proposing the remedy of neutralization (instruction in both concepts) or elimination of evolution instruction. A model bill containing such provisions has been introduced into at least 4 state legislatures. "Scientific" creationism is therein defined as belief in special creation, fixity of originally created kinds of organisms, distinct ancestry of man and apes, a world-wide flood and recent origin of earth and life. Evolution is also defined along with evidence to be used in teaching both concepts. The action clause provides that if evolution is taught, creationism must also be taught in a balanced fashion. If passed into law, science teachers would be required to teach theology and scientific truth as defined by law, not science. Appropriate responses include developing professional competence in evolutionary theory, education of the public and political activity. NABT has organized a committee of Evolution Education and will publish a newsletter drawn from material in its files.

MATHEMATICS FOR ELEMENTARY SCHOOL TEACHERS: AN ACTIVITY APPROACH. Delbert Snyder*. Dept. of Mathematics, Eastern Mennonite College, Harrisonburg, VA 22801.

Based on the assumption that mathematics learning is enhanced when children are actively involved in manipulative experiences, the Fresno Pacific Mathematics Project, headed by Dr. Arthur Wiebe, has developed a series of inservice courses for elementary teachers which provide materials and expertise necessary to implement an activity-oriented approach to elementary mathematics. A second objective of the Project is to improve teacher attitudes toward mathematics, since it is believed that a major block to improved mathematics instruction is unfavorable teacher attitudes.

The Project courses and materials have been used by more than 5000 teachers in California, Oregon and Virginia over the past eight years. Conclusive results are not available, but informal field studies indicate that improvements in both student learning and teacher attitudes have occurred through this program. In one study, 196 teachers used the materials in their classes over a period of 60 days for 5-7 minutes per day to drill and reinforce basic computation skills. Test results show that their students gained an average of 1.3 grade levels in those skills during that time period. In another survey of 4000 teachers, 75% stated that their involvement in the Project had resulted in a marked improvement in their attitudes toward mathematics; for 10%, mathematics had risen from a dreaded subject to a favorite subject due to increased confidence and student enthusiasm.

BIOETHICS: ADOPTED OR STILL ORPHANED? P. J. Thompson, K. A. Banschick, C. J. Boyne, C. A. Chiaromonte, L. M. Crowley, J. D. Dickens, D. D. Leonard, and J. R. Smith. Dept. of Biology, Univ. of Va., Charlottesville, Va. 22901

Bioethical issues surfaced when scientists--through increased technology--learned to manipulate natural life processes. A systematic examination of four major science journals demonstrates fluctuating coverage of bioethical issues in the last decade. A survey of six widely-used general biology textbooks illustrates a gradual increase in coverage. Preliminary examination of a timeline of bioethical issues for the past ten years suggests possible historical correlates for these observations.

Engineering

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

CO₂ TRANSPORT IN BRAIN CHEMORECEPTORS. J. Milton Adams* and M. L. Severns*, Div. Biomedical Engineering, Univ. of Va., Charlottesville, Va. 22908

One of the primary inputs which controls breathing is the CO₂ partial pressure of arterial blood (PaCO₂). The processes involved include convective and diffusive transport in a spatially random network of capillaries. Using the distributed parameter Krogh model (two concentric cylinders) we have developed a lumped parameter compartmental model which predicts the time course of spatially averaged PCO₂ of chemoreceptor tissue ($\bar{P}tCO_2$). If the solution for $\bar{P}tCO_2(r,t)$ is formed for a step change in PaCO₂ in the diffusion limited case, a series of Bessel functions results. We next solve for the trans-compartment flux (from the Bessel series) which is: $\dot{n}_{CO_2} = K\bar{P}tCO_2/\partial r|_{r=a}$. Since the first term from the resulting series accounts for 98% of the total flux, a first order process will be appropriate. The lumped parameter mass transfer coefficient is chosen to give the same flux as for the Krogh model. We then integrate the steady state solution to find $\bar{P}tCO_2$, which for brain is: $\bar{P}tCO_2 = (Pa + Pv)/2 + 1$ (mmHg) where Pa and Pv are arterial and venous PCO₂ respectively. The main difference between this lumped model and previous ones is that the $\bar{P}tCO_2$ is not equal to $PvCO_2$. In addition, we have shown how the compartmental model relates to the Krogh predictions. (Supported by NIH grant GM 07593).

A HIGH-SPEED CENTRIFUGE FOR REMOVING FLY-ASH FROM FLUE GAS. R. J. Babarsky* and S. S. Fisher, School of Engr. and Appl. Sci., U. Va., Charlottesville, VA 22901.

The design of a high-speed centrifuge for separating fly-ash particles from a continuous flue-gas stream is described. The device consists of an impeller (similar to that for radial compressor) which accelerates the gas to high angular velocity, a multiple-annulus settling chamber in which the fly-ash particles are removed, and a second impeller used to decelerate the gas after separation is complete. Because this centrifuge rotates at very high speeds (400 m/s rim speed), in order to keep windage-type losses small, it must be operated within a reduced-pressure casing. It must also be equipped with a system for removing collected particulate matter during operation. The specific centrifuge described is suitable for continuous separation of particles as small as 0.1 μ m at a gas throughput of 5 m³/s. Its operating power requirement is approximately 30 kW.

SIMULATION FOR A SOLAR ENERGY SYSTEM FOR INSECT CONTROL. J. T. Beard, F. A. Iachetta, G. C. Alling, H. J. Manning, Dept. of Mech. and Aero. Engrg., Univ. of Va., Charlottesville, Va.,

A Virginia Academy of Sciences presentation in 1979 described a proposed solar-powered cooling system for an agricultural storage warehouse. The justification for such a system was also discussed.

This paper describes a computer model which was written to simulate the operation of the system. Weather data from Raleigh, N.C. were used to model the system throughout an average year. Results of the simulation are presented and compared to measured data; verifying the accuracy of the model.

The model was used to evaluate and size the important cooling-system parameters such as the collector, refrigerator and latent heat storage tank. The results of this evaluation are presented.

EXPERIMENTAL VIBRATION ANALYSIS OF THE SPACE SHUTTLE MAIN ENGINE HIGH PRESSURE TURBOPUMPS. J. R. Biele, R. D. Flack*, and E. J. Gunter*, Dept. of Mechanical and Aerospace Engineering, University of Virginia, Charlottesville, VA 22901.

For the past three years, the Space Shuttle Main Engine (SSME) has been plagued by high pressure turbopump reliability problems. These problems are caused by high vibration amplitudes in pump operating speed ranges and result in decreased pump seal and bearing life. Vibration data from accelerometers externally mounted on the turbopumps has been analyzed using 1) a tracking filter to obtain plots representing synchronous response versus pump rotational speed, and 2) a Fast Fourier Transform Frequency Analyzer to plot vibration spectrums. These plots have been examined for evidence of fluid whirl in pump seals, pump critical speeds, and the vibrational interaction between the fuel and oxidizer pumps.

Specific conclusions resulting from this experimental work include:

- 1) The oxygen pump seals may only be marginally stable at the pump running speed corresponding to SSME rated power level.
- 2) A strong resonance is present in the oxygen pump at the SSME rated power level.
- 3) Hydrogen pump 1st and 2nd critical speeds occur at 16,300 and 33,000 RPM.
- 4) Internal rotor behavior cannot always be accurately determined through use of externally mounted instrumentation.

DESIGN OF CAPSULES FOR IRRADIATION OF REACTOR PRESSURE VESSEL STEELS IN THE UNIVERSITY OF VIRGINIA REACTOR. C.A.Bly*, J.L.Kelly* and B.L.Shriver. Dept. of Nucl. Engineering & Engineering Physics, Univ. of Va., Charlottesville, Va. 22901.

Fast neutron damage to reactor vessel steels is known to result in reduced ductility which may increase in the possibility of brittle fracture.

In support of a study of the mechanisms by which fast neutron irradiation damages steel, an irradiation capsule and holder has been designed which allows precise determination and control of the neutron flux and specimen temperature during irradiation. Design calculations involved a coupled analysis of radiation attenuation and its attendant heating, additional heating supplied by resistance heaters, and heat transfer and fluid flow which apply to the capsule geometry.

Systems engineering considerations included component reliability and availability, and the requirement that the design remain within the fabrication capabilities of our machine shop. A "dummy" capsule has been used to assure all design criterion were satisfied.

This design could serve as a prototype of single-fuel element sized, irradiation capsules that could be used at all nuclear research facilities using standard MTR type fuel elements.

TECHNICAL AND NON-TECHNICAL COMMUNICATION PROBLEMS INVOLVED WITH ENERGY CONSERVATION PROGRAMS. C. A. Conner. Univ. of Virginia, Charlottesville, Virginia 22901

This presentation is concerned with the communication problems involved with the development and conduction of energy conservation programs dealing with public buildings. The laws and regulations involved in the development of the Grants Program for state energy conservation along with communication problems encountered will be studied first. Next, the energy audit approach and forms developed by the Center for Energy Analysis for the State of Virginia will be analyzed with respect to their requirements and weak or strong communication points. The development and results of this form will be presented along with the several studies and surveys of communication problems conducted. Conclusions and recommendations relating the problems and solutions will be presented for the State of Virginia's energy conservation program.

MEASUREMENT INTERMITTENCY CORRELATION USING A LIGHT SCATTERING TECHNIQUE. Godfrey Fien, Dept. of Mech. and Aero. Engr., U. Va., Charlottesville, Virginia 22901.

An axisymmetric air jet, coflowing with windtunnel air is marked with an aerosol. At the same time two volumes some distance apart but in the boundary regions of the jet flow are illuminated with different colors of laser light. Whenever aerosol particles contained in the jet flow pass through the illuminated volumes light is scattered, rendering the jet flow in the volumes visible. This scattered light is detected by photo diodes. It is then processed electronically to give measurements of correlation between the portions of flow bounded by the two control volumes. These measurements show just over how much time and space the shape of the boundary between the jet flow and wind-tunnel flow changes completely.

DEVELOPMENT AND TESTING OF PROTOTYPIC BREEDING BLANKETS FOR FUSION REACTORS. C. S. Caldwell*, R. E. Womack*, J. K. Schmotzer*, and W. G. Pettus, Lynchburg Research Center, Babcock & Wilcox Co., Lynchburg, Va. 24505.

The development of a test design for measurement of tritium or fissile yields in prototypic fusion reactor blankets is described. Using neutrons from TFTR, results can provide early proof of neutronic design methods and self-sufficiency of tritium breeding, both vital issues for future toroidal-geometry D-T burning reactors. Tests of a module in the Tokamak Fusion Test Reactor can provide data by 1985.

Functional requirements, and selection criteria for a lithium oxide array are given. Measurement procedures for neutron fluence and tritium production are outlined. The TFTR will produce $\frac{1}{2}$ -second pulses of D-T fusion neutrons (14 Mev) with a flux of 3 to 4×10^{12} n/cm²/sec at the vacuum vessel wall. The module is rectangular with a frontal area of 0.4 m^2 . The Li₂O is contained in Zr tubes on a tight-packed triangular pitch. Rods can be oriented radially or vertically, and rod spacing/coolant/reflector/multiplier combinations can be adjusted for parametric tests. Diagnostics include dosimetry "rabbits" and strain gages.

Neutronics predictions using transport and Monte-Carlo codes will be compared with profiles of tritium, neutron fluence, and gamma dosimetry.

STUDIES OF FRACTURE IN ADHESIVELY BONDED POLYMER COMPOSITES. David W. Dwight and Ronald J. Vuz*. Dept. of Materials Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The principal objective of this study was to develop methodology to provide useful analysis of the critical parameters involved in lap shear failures of reinforced polymer sheet-molding compounds, adhesively bonded with two-component polyurethanes. He employed neutron radiography in an attempt to study inherent flaws in the glue line. Surface analytical techniques included X-ray Photoelectron Spectroscopy (XPS or ESCA) to determine surface atomic compositions, and Scanning Electron Microscopy (SEM) to study fracture surfaces. Also, optical microscopy was used for fractography, as well as to observe microstructures in cross-sections near the locus of failure. In this paper we present initial correlations between shear strength, surface analysis, non-destructive testing and fractography.

SOLAR ENERGY IN NORWAY? J. B. Freim*, Babcock & Wilcox Company, Research & Development Division, Lynchburg, Virginia

A technical and economic assessment of the use of solar energy in Norway was performed. The study analyzed active liquid and air solar systems to provide space heating and water heating.

The five Norwegian cities used in the study are Oslo, Bergen, Kise, Trondheim, and Troms; these cities were selected because their temperature, sunlight, and wind conditions differ. The Norwegian Meteorological Institute selected a "typical" weather year for each city; the weather data was used in the calculations.

A typical one family house was chosen; seven different insulation standards for these houses were investigated. The Norwegian program, ENCORE (Energy Consumption in Residential buildings) was used to calculate the heat loads for this house for the "typical" year.

Seven solar collectors were used. Three are Norwegian, one from Germany, and three from the USA. For each collector, a plot of efficiency as a function of temperatures and solar insolation is needed.

The program FCHART, obtained from the Solar Energy Laboratory at the University of Wisconsin, was used to determine collector performance and economics.

The most interesting results are the following:

- Good economics for a Norwegian collector
- Efficient use of solar in northern part of Norway
- Simplified construction by hanging collectors in the outside of buildings

BIPOLE TRAJECTORIES. W. P. Harrison, Jr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A mathematical procedure which can be used to analyze the motion of north-south bipoles traversing a magnetic field of distributed flux density is discussed and demonstrated. An example of X-direction trajectories at constant height over a flat magnetic sheet with a uniform north monopole flux density distribution is shown. It is concluded that the method discussed can be used to analyze a wide variety of problems involving the motion of bipoles both far from and in the near vicinity of arbitrarily distributed flux density fields.

GEOTHERMAL WELL-EARTH COUPLED WATER SOURCE HEAT PUMP SYSTEM FOR RESIDENTIAL HEATING AND COOLING. F. A. Iachetta, Dept. of Mech. and Aero. Engr., Univ. of Va., Charlottesville, Va. 22901

The earth is used as an energy source-sink for a heat pump with a buried closed loop water circulating system. Water circulates in a loop consisting of a horizontal run of pipe buried two feet below the frost line, combined with a heat exchanger submerged in a 250 ft. deep well and a water to Freon 22 heat exchanger which is connected to a modified heat pump. No water is pumped from the ground which in effect renders this a geothermal system.

Seasonal COP of 2.7 to 3.0 is realizable compared to 1.6 to 2.0 for conventional air-air heat pumps. Defrost and auxiliary heat requirements are eliminated and the balance point is raised. Energy requirements for the heating cycle are reduced up to 50% compared to air-air systems and up to 25% when the system operates in the cooling mode. Power required to circulate water in the earth coupled loop is 185 watts, substantially below the energy required to pump water from the ground.

AN ACTIVE DOSIMETRY SYSTEM FOR THE ENVIRONS OF A NUCLEAR POWER PLANT. W. R. Johnson*, G. C. Carlson*, M. A. Pope*, D. W. Varney*, Dept. of Nuclear Engineering, Univ. of Va., Charlottesville, Va. 22901

A system has been designed to monitor the area surrounding a nuclear power plant with active gamma-ray dosimeters. The signals from these devices are fed to a central processor at the plant which will store, process and display radiation dose information. A novel gamma-ray dosimeter has been developed which is relatively inexpensive and has a wide range of linear response in both dose rate ($\sim 10^{-6}$ to 10 R/hr) and photon energy (0.06 MeV to 3 MeV). The system would include 50 to 100 dosimeters in concentric rings around the plant out to a distance of 1 to 2 miles. During normal operations the system would perform a routine radiation monitoring and data storage functions. In the event of an abnormal radioactivity release the system would automatically shift to the accident mode and notify operators of higher than normal offsite dose rates. The system computer would predict population doses and maximum offsite doses from the dosimeter data, meteorological condition input, and stored site population data. The computer system can generate estimates of the magnitude of the radiation release. This information will enhance operator understanding of accident details and provide rapid guidance as to protective measures to be initiated. The system's output and diagnostic capability may also be provided in parallel to a state emergency preparedness office.

DEVELOPMENT OF AN ANALYTICAL MODEL FOR ICE ACCRETION. R. D. Kirchner, Institute for Hypersonic Studies, Inc., 7602 Cornwall Road, Richmond, Va. 23229

Ice accretion on aircraft surfaces and ice ingestion in engines can cause significant degradations in flight performance and catastrophic engine failure. Analytical and numerical models of the ice accretion process have been hampered in the past by a lack of understanding of the density of the accreting ice/air mixture.

An analytical approach has been developed by which the density of accreting ice can be predicted. The approach assumes that impacting water droplets diffuse through the existing ice structure according to Fisk's law of diffusion, with the mass and heat transfer being coupled by means of the Colburn analogy and the Reynolds analogy for pipe flow. Nusselt numbers were taken to be a function of Reynolds number and Prandtl number according to the accepted techniques of Knudsen and Katz.

The ice accretion model was used to predict ice densities for impacting water droplets with momenta ranging from 20 to 440 mJ/sec with temperatures varying from -5 to -30°C . Predictions were found to agree favorably with the experimental results of Macklin.

AN APPARATUS TO DETERMINE THE DIRECTIONAL EFFECT IN THERMAL CONTACT RESISTANCE AT METALLIC INTERFACES. D. L. Padgett and L. S. Fletcher, Dept. of Mech. and Aero. Engr., U. Va., Charlottesville, Va. 22901

The resistance to heat flow caused by an interface between two contacting materials is defined as the thermal contact resistance. The necessity of knowing exact heat transfer characteristics in applications such as nuclear reactors and spacecraft has recently brought increasing importance to this area of study. Thermal rectification is a directional bias which occurs when heat flows between two dissimilar metals in contact. Rectification is evidenced by different contact resistance values when the heat flow direction is changed.

The University of Virginia currently has a project underway to investigate thermal contact resistance and thermal rectification. The first step of this project, to design a reliable test facility, has been completed. This apparatus allows the investigation of thermal contact resistance at higher pressures and temperatures than previously possible, and it also has the capability to reverse the heat flux direction to obtain reliable data on thermal rectification.

STAFFING ANALYSIS AND VOLUME EVALUATION - "SAVE" - FOR SMALL POST OFFICES. L. A. Rowe* and J. P. Saunders*, U.S.P.S., Roanoke, VA 24022; and K. P. Boward, An. Sci. Dept., VPI & SU, Blacksburg, VA 24061

For one week in July 1976 data were collected in 18 second class and 31 third class post offices having similar work load and community service requirements in the Roanoke area management sectional center. Using a similarity constraint that each post office would work only single zip incoming final destination mail, a multiple regression analysis was performed. The dependent variable was total office staffing hours; observed mean 68.1 ± 30.4 hr. Independent variables, listed in decreasing order of importance, each preceded by its partial regression coefficient and followed by its observed mean, resp., were: .0138 X_4 , incoming mail, 2137.7; -.14 X_7 , class of post office, 2.6; .0454 X_6 , number of lock boxes rented, 141.2; -.0182 X_3 , pieces of mail cancelled 483.9; .0642 X_1 , number of window transactions, 102.5; -.1213 X_5 , hrs. of rural carrier service, 54.1; and, .0041 X_2 , outgoing volume by type, 674.7. All but the last were significant ($P < .10$). The Y-intercept was 75.4. The regression analysis reduced the C.V. from 44.6 to 13.8; $P < .001$; the multiple correlation, R, was .957. Results from this study provide basic and essential information reflecting the present state in the art of managing accountability for small post offices.

COMPUTER-AIDED DESIGN OF AIR CONDITIONING AND HEAT PUMP SYSTEMS. T. C. Scott. Department of Mechanical and Aerospace Engineering, University of Virginia, Charlottesville, Virginia 22901

This paper examines the response of the engineering community to the current demands for more efficient air conditioning and heat pump systems. Past and present design and testing techniques are discussed and evaluated and the extent to which computer-aided design has been incorporated by the industry is reviewed. The areas where research is needed are many, but of more importance is the need for information transfer from researchers to practitioners.

NEUTRONICS CALCULATIONS FOR A PROPOSED PROTOTYPIC BREEDING BLANKET MODULE. F. C. Welfare* and W. G. Pettus. Babcock and Wilcox Company, Research and Development Division, Lynchburg, Va. 24505

For many years the effort in fusion power development has been focused on questions of plasma physics. Recent progress in this area now requires investigation of the engineering questions involved in fusion power systems. One such engineering question deals with the design of fusion blankets which will serve two purposes: (1) converting the energy released into a useful form and (2) breeding fuel either for the fusion system or for other energy systems. This paper presents neutronics calculations for an experimental blanket module which should be prototypic of blankets for power reactors and which is designed for use with the TFTR fusion device. The ability of this module to breed tritium as fuel for a fusion device has been evaluated in an extensive series of calculations. These calculations show that tritium breeding ratios in the neighborhood of 1.45 are obtainable. The spatial variation of the tritium yielding reactions has also been calculated as has the ability to breed materials other than tritium.

Environmental Science

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

ENVIRONMENTAL PERCEPTIONS, RECREATIONAL BEHAVIOR, AND MANAGEMENT PREFERENCES OF LAKE PROPERTY OWNERS. L. A. Helfrich*, M. B. Bain*, and D. L. Weigmann*. Virginia Polytechnic Institute and State Univ., Blacksburg, VA 24061.

This study was designed to provide a basic understanding of lake property owners and their potential role in formulating lake management policies. A 50-item mail questionnaire was used to collect data on the characteristics, recreational use patterns, perceptions and preferences of lake property owners.

Solitude, natural beauty, economic considerations, and water-based recreational opportunities were the principal reasons cited for lake property ownership. Swimmers comprised the largest and most active user group. The subjective assessments of lake shore residents concerning various attributes of water quality, shoreline development, neighborhood conditions, and recreation pressure, accurately reflected the prevailing environmental conditions based on objective limnological measurements. Our respondents' selection of management activities were directly related to their environmental perception and appropriate for the existing conditions. Lake property owners were particularly sensitive to water clarity, sedimentation and erosion problems, strongly supported most proposed management activities, and appeared willing to restrict their recreational activities to protect environmental quality.

SURFACE CIRCULATION AND HORIZONTAL DIFFUSION PROCESSES OF THE LOWER CHESAPEAKE BAY. R.E. Johnson and F.A. Hilder*. Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508

A Lagrangian method utilizing clusters of four or five buoyed drogues is used to study the surface circulation and horizontal diffusion. The study area in lower Chesapeake Bay encompasses some 160 km² and includes the area north of Thimble Shoal Channel, southwest of Chesapeake Channel and west of the Chesapeake Bay Bridge and Tunnel.

The surface current is seen to be of a rotary type which is not inconsistent with a tidally dominated wide estuary where Coriolis force can be significant.

The horizontal diffusivity, as represented by Richardson's neighbor diffusivity concept, appears to confirm the applicability of the "4/3 power law" to the study area.

EFFECTS OF ARSENATE ON ALGAE, DAPHNIA, AND MOSQUITO FISH. S. Jurewicz* and A. L. Buikema, Jr. Dept. of Biology Va. Polytechnic Inst., Blacksburg, Va. 24061.

Toxicity tests, using sodium arsenate, were performed on *Chlamydomonas reinhardtii*, *Daphnia pulex*, and *Gambusia affinis*. The algal test was adapted from the EPA method. The animal tests were static without renewal, and conducted at 20±2°C., and a 16L:8D photoperiod. The 14 day 50 and 95% inhibition of algal growth (95% f.l.) were 202 (197-206) and 264 (254-278) mg/l, respectively. Stimulation of biomass occurred up to 151 mg/l, with maximum stimulation averaging 73% above controls at 100 mg/l. The mean cell diameter and variability of diameters increased as concentration increased. Also, at the higher concentrations, a greater proportion of cells had an enlarged gelatinous mucilage, were nonmotile, and lacked flagella. The 24 and 48 hr LC50s (95% f.l.) for *Daphnia* were 10.3 (6.6-14.0) and 3.6 (3.3-3.9) mg/l, respectively. Individuals were nonmotile up to 3 hrs before death. The 48 and 96 hr LC50s (95% f.l.) for *Gambusia* were 57 (51-64) and 49 (44-54) mg/l, respectively. Loss of equilibrium, lack of motility, and hemorrhaging of the gill and opercular region were observed.

VIRGINIAN SEA PLANKTON ASSEMBLEDGES AND THEIR RELATIONSHIPS TO SHELF-SLOPE WATER MASSES, 1978-1979. C. E. Meyer* and H. M. Austin, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia 23062.

The shelf and slope water masses on the Continental Shelf of the southern Virginian Sea can be delineated by their planktonic and physical characteristics measured by Continuous Plankton Recorder (CPR) and Expendable Bathythermograph (XBT) transects on USCG cutters. Shelf waters are differentiated from slope waters by year round higher standing crops of phytoplankton and zooplankton. Phytoplankton species diversity is higher in shelf waters year round while dominate zooplankton diversity shifts between shelf and slope waters seasonally. The water masses can also be differentiated by dominate copepod species less than 2.0mm. Shelf waters support principally, *Para-pseudocalanus* and *Centropages typicus* while slope waters support *Pleuromma*, *Oncaea*, and *Oithona*.

The vertical seasonal thermal structure and surface salinities indicate the position of the shelf-slope front by changes in the inclination of the isotherms and surface salinity gradients (shelf < 33 o/oo, slope > 35 o/oo).

THE DISTRIBUTION OF CS-137 AND SOME HEAVY METALS IN VARIOUS SEDIMENTARY ENVIRONMENTS OF THE JAMES RIVER ESTUARY. C.S. Moy*, G.T.F. Wong*. Dept. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508

The concentrations of Cs-137 and several heavy metals were measured in sediment cores taken from a variety of sedimentary environments of the James River Estuary. The sedimentation rates range from 2 to 18 mm/yr as determined by the distribution of Cs-137. Sediments in a low energy environment (Burwell Bay) contains the highest percentage of fine grain material (<63 μ m) and the highest concentrations of Cs-137 (>2pCi/g). In higher energy environments (Point of Shoals, Rockland Shoal Channel and Warwick River), the sediments contain 15-95% of fine grain material depending on the amount of oyster shell debris and lower concentrations of Cs-137 (<1pCi/g). The vertical distribution of Cu is fairly constant (<50 μ g/g). The concentrations of Zn (50-250 μ g/g) vary with concentrations of Cs-137.

THE TEST-BED AIRCRAFT MULTISPECTRAL SCANNER. Weldon Staton*
NASA Langley Research Center, Hampton, Va. 23665.

In recent years, NASA Langley has been engaged in remote sensing of the marine environment using airborne optical scanners. About a year ago, NASA Langley embarked upon the task of building a multichannel scanner to be used as a research tool in marine applications. This tool is an instrument called the Test-Bed Aircraft Multispectral Scanner (TBAS). The instrument can be used for land as well as marine studies. Forests, grasses, and crops can be mapped, in addition to phytoplankton and suspended sediment.

The TBAS instrument consists of nine spectral bands, eight which include visible and near infrared and one infrared. Design of the system is such that research flexibility is achieved. The rationale behind the development of the TBAS instrument will be presented. Examples of data acquired with the system will also be presented.

A STUDY OF THE FIRST THREE MONTHS OF THE PRIMARY SUCCESSION OF ADAM'S LAKE. Carolyn L. Thomas, Barry G. Hughes*. Dept. of Biology, Ferrum Col., Ferrum, Va. 24088

The purpose of this study was to do a limnological survey of the first three months of the primary succession of Adam's Lake on the Ferrum Col. Campus. It was tested for its dissolved oxygen content, water temperature, turbidity, pH, nitrate and orthophosphate content, zooplankton, and phytoplankton. Representative samples taken from various sites demonstrated the fluctuations of the different tests.

Results of the study showed how the integration of factors in an aquatic system determine its productivity. There are numerous cause and effect relationships in such a system. Some factors seemed to be influenced by this integration, while others were independent.

CORRELATIONS BETWEEN CLIMATOLOGICAL FACTORS AND THE COMMERCIAL BLUE CRAB CATCH IN CHESAPEAKE BAY. W. A. Van Engel, and R.E. Harris, Jr.*. Va. Inst. Mar. Sci., Sch. Mar. Sci., Col. William and Mary, Gloucester Point, Virginia 23062.

Climatological factors immediately preceding spawning and in the first eight months of life of blue crabs (*Callinectes sapidus*) are major factors in establishing the ultimate population size, as measured by the Chesapeake Bay commercial catch. Monthly values of climatological and environmental data were lagged up to 24 months prior to the Biological Year catch, the sum of monthly landings from September through August. Correlation coefficients between 20 variables and the catch were larger than ± 0.58 , and significant at the 0.025 percent level (one-tailed test). Cooling degree days at Norfolk Airport (May 2, $r=0.77$), meridional wind stress and zonal Ekman transport at Cape Hatteras (both in Sept. 2, $r=-0.65$), water salinity at Kiptopeke Beach (Oct. 1, $r=0.64$), and Chesapeake Bay streamflow at the mouth of the bay (Oct. 1, $r=-0.64$) were the events most highly correlated with catch but not co-correlated. The notations May 2, Sep. 2 and Oct. 2 refer to the month and the number of Biological Years preceding the catch.

REPETITIVE AERIAL PHOTOGRAPHY FOR ASSESSING MARSH VEGETATION CHANGES. M.G. Weaver*, G.H. Cross, and R.A. Mead*. Schl. of For. & Wildl. Res., Va. Polytechnic Institute, Blacksburg, Va. 24061

The dynamic conditions of two marshes on the Rappahannock River, Virginia, were investigated using sequential aerial photography. All the historical photography was 9 inch format, black and white panchromatic, medium scale, purchased from various government agencies. Recent photos were large scale 35mm color infrared and natural color positive transparencies. Vegetative classes were delineated on the recent photographs to produce a large scale 1:2500 map useful in current resource planning and future monitoring. The black and white historical photos were interpreted using a generalized classification system. Comparisons of changes were made by reducing the current vegetation classes to a common scale of 1:7000. In addition, muskrat lodges were plotted on all photographs where resolution and quality permitted. Repetitive aerial photographs provided useful information on which to formulate hypotheses that would explain changes in marsh vegetation.

A STUDY OF CLIMATE CHANGE IN SOUTHEASTERN VIRGINIA FROM 1933-1977 USING THE THORNTHWAITE INDICES OF CLIMATE CLASSIFICATION. S. M. Zubrick* and N. Aldridge*. Dept. of Geophysical Sciences, Old Dominion Univ., Norfolk, Va. 23508

Using a modified Thornthwaite evapotranspiration formula within a water budget model, monthly actual evapotranspiration values were derived for six Southeastern Virginia stations over a forty-five year interval. The computer program yielded annual values of the Thornthwaite indices of climate classification for the six sites. It required only the monthly precipitation, mean temperature, and estimates of soil water-holding capacity for each location.

A qualitative correspondence among the six stations in the pattern of climate change was revealed using this classification system.

Geology

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

POST-YORKTOWN TIDAL DEPOSITS IN THE UPLANDS OF JAMES CITY COUNTY, VIRGINIA. C. R. Berquist, Jr. and K. W. Ramsey*. Va. Div. of Mineral Resources, c/o Dept. of Geology, College of William and Mary, Williamsburg, Va. 23185

Numerous localities within the central part of James City County, Virginia have provided excellent exposures of the Yorktown Formation (Early Pliocene) and the overlying upland sediments. These uplands were formed in tidal environments and consist of tidal channel, tidal flat, and lagoonal deposits. They are thought to represent a late Pliocene to Early Pleistocene barrier island-estuarine system which deposited material when sea level was greater than 50 feet.

A RECONNAISSANCE STUDY OF THE GEOLOGY OF THE SOUTHERN HALF OF THE RICHMOND BASIN, VIRGINIA. Bruce K. Goodwin, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185.

South of latitude 37°30', Upper Triassic sedimentary rocks of the Richmond Basin occur within the Hallaboro, Clayville, Winterpock, Mannboro, Church Road, and Hebron 7½ quadrangles. Four mappable rock units occur here: (1) coarse conglomerates; (2) coal measures, including lower barren beds; (3) light to dark gray, dominantly lacustrine, sandstone and shale; and (4) reddish fluvial sandstone. Total thickness of the Triassic rocks is unknown but may exceed 4,000 feet. One deep drill hole has shown that the reddish sandstone, previously thought to be only 500 feet thick, is over 1,500 feet thick. Massive conglomerates occur locally along the basin's margin adjacent to faults. Coal measures lie unconformably upon the basement complex along the northern and southern segments of the basin's eastern margin. The coal measures are absent in a complexly faulted central area of the eastern margin, and have not been found on the basin's western margin in the area of this study. The basin is usually bounded on its western side by normal faults and that border may be step faulted. In general, bedding strikes north northeast and dips gently westward across most of the basin. Local reversals of dip and deviations of strike delineate some flexures and suggest faulting within the basin. Near faults along the basin margins, bedding often strikes parallel to the faults and dips in toward the basin.

LARGE QUARTZ CRYSTALS FROM ROCKINGHAM COUNTY, VA.

Barry W. Miller*, James L. Beaver, Jr.*, F. H. Campbell III, Dept. of Geology, James Madison Univ., Harrisonburg, Va. 22807

In April 1979, a number of unusually large, singly terminated quartz crystals were found associated with the Beekmantown Dolomite in Rockingham County. The crystals were initially noticed in rock piles in a wooded ravine along the Shenandoah River. No large crystals were found in situ or associated with matrix material; however, a float specimen of breccia was found which consisted of saccharoidal dolomite fragments enclosed by veins of white, crystalline dolomite. Within a cavity on this specimen are moderate-sized milky quartz crystals growing over small, gray, rhombohedral crystals of dolomite. Several mineralized collapse breccias in this area are believed to have formed as a consequence of activity along the nearby North Mountain thrust fault. Three potential sources of silica exist within the Beekmantown; and numerous rhombohedral impressions are found on many of the large quartz crystals. This suggests that these crystals formed in a mineralized collapse breccia.

1300 MILLION YEAR OLD ROCKS IN EASTERN NORTH AMERICA.

Douglas Mose and Susan Cohen*, Dept. of Chemistry and Geology, George Mason University, Fairfax, Va. 22030
U-Pb and Rb-Sr age determinations from Precambrian rocks in the Grenville Province of eastern North America have revealed the presence of 1250 to 1350 m.y. old rocks in an area generally considered to be composed of rocks less than 1150 m.y. old. Reported data include 1280 m.y. old gneisses in Pardee Point, Tennessee (Davis and others, JGR, 1962), 1225 m.y. old Cranberry Gneiss in North Carolina (Fullagar and Odom, GSA Bul., 1973), 1300 m.y. old Baltimore Gneiss in Maryland (Tilton and others, Studies of App. Geology, 1970), and 1350 m.y. old Adirondack rocks in New York (Spoonor and Fairbairn, JGR, 1970). New data on the Fordham Gneiss in the Manhattan Prong and the Reservoir Granite in the Reading Prong, both in southeastern New York, and new data from two areas in the southeastern Adirondacks of upstate New York show that the Manhattan Prong, Reading Prong and Adirondacks contain 1300 m.y. old rocks. Present studies are concentrating on the mechanism by which radiometric "clocks" responded to the widespread 1000 m.y. old Grenville metamorphic event.

GEOLOGICAL CONSERVATION PROBLEMS OF CAVES AND ASSOCIATED KARST AREAS OF VIRGINIA. Roy D. Powers*, Mining and Technology Division, Mountain Empire Community College, Big Stone Gap, Va. 24219

Over the past few decades as the growth rate of Virginia and her neighboring states has increased, the conservation problems concerning caves and associated karst areas have risen to a high level. Population pressure has caused an overloading of many karst areas resulting in severe damage to the geology of these areas.

Problems associated with this population growth include groundwater pollution, indiscrete refuse dumping, wanton vandalism, formation mining, and destruction resulting from highway and dam construction.

A complex network of various organizations has evolved to help combat these problems.

TECTONIC AND GEOMORPHOLOGIC IMPLICATIONS OF JOINING IN BRUSH MOUNTAIN, MONTGOMERY COUNTY, VIRGINIA. Noel G. Simmons*, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

The Price Formation of Brush Mountain forms the major structural front northeast of the Pulaski overthrust sheet. The stratigraphy (Kreisa & Bambach, 1973) consists of a basal Cloyd Conglomerate, which is the primary ridge-former, and an overlying non-marine cyclic sequence of terrigenous sandstones and mudstones. The Merrimac Coal seam is a member of this formation.

Northeastward from New River, the formation strikes linearly for 2 1/2 miles after which the mountain develops a broad "s"-shaped curvature before returning to a nearly linear ridge farther northeast. Resequenced streams have incised the Price, and from the differential weathering of the cyclic sandstones and mudstones produced cusp-shaped secondary ridges disposed regularly along the southeast flank of the mountain. The formation is cut by extensional normal faults as described by Kreisa (1972) as well as prominent joints.

The joints were mapped and plotted by means of a stereonet to determine whether they are the products of Pulaski overthrusting and to see if there is a relationship between jointing and the unusual curvature of Brush Mountain.

STRATIGRAPHIC VARIATIONS OF THE SILURIAN SYSTEM IN THE CATAMBA SYNCLINE, ROANOKE AND MONTGOMERY COUNTIES, VIRGINIA. Robert R. Seal, III*, Dept. of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

The doubly plunging, northeast trending Catamba syncline of the Pulaski overthrust sheet exhibits striking stratigraphic variations of the Silurian System. The variations are typified by two localities 17 miles apart. The first near Catamba along Virginia Route 311 is 3 miles up the northwest limb from the trough and depression of the syncline, and the second at Fagg is in the trough at the southwestern nose of the syncline. The Silurian section along 311 is approximately 300 feet thick beginning with 20' of clean conglomeratic Tuscarora Sandstone, followed by 75' of hematitic Rose Hill sandstone and interbedded shale, in turn, overlain by 175' of moderately clean, cross-bedded Keefer Sandstone. At Fagg, the entire Silurian section is represented by only 5 1/2' of Tuscarora-like conglomeratic sandstone, bounded by unconformities.

These stratigraphic variations can be attributed to differential axial subsidence during Silurian time of the Catamba syncline, the first major downwarp northwest of the Blue Ridge anticlinorium.

GEOTECHNICAL ASPECTS OF THE CHIMBORAZO PARK SLIDE, RICHMOND, VIRGINIA. Ronald J. Tucker, Virginia Department of Highways and Transportation, P. O. Box 391, Petersburg, Va. 23803

Historic Chimborazo Park in Richmond, Virginia, situated on a terrace overlooking the James River, has been plagued by landslides for over 70 years. A serious slide in January 1978 that forced the temporary closing of Route 60, led to the present investigation and to remedial efforts at permanently controlling the situation. A grid work of hollow-stem borings were made that provided detailed information on soil types and moisture content and provided undisturbed soil samples for tri-axial testing in the laboratory. Additionally, slope inclinometer casing was installed and data obtained at regular intervals.

Evaluation of the data led to the conclusion that the problem resulted from an already unstable slope that was further weakened when prolonged rainfall added ground water at a rate faster than could be dissipated through the soil. This led to an increase of hydrostatic pressure which consequently reduced the shear strength of the soil.

From several alternatives, it was decided the most economical approach would be to control ground water through the use of a horizontal drain system. Sixteen drains were installed a total length of 3700 feet. The drain system is discharging ground water at rates ranging from 32 to 41 gallons per minute and can be correlated closely with rainfall in the area. To date, the drains have stabilized the slope and further movement has not been detected.

ENVIRONMENTAL INFORMATION AVAILABLE FROM TOPOGRAPHIC MAPS H. W. Webb, Jr., Va. Div. Mineral Resources, Charlottesville, Va. 22903.

Topographic maps portray a variety of information useful for environmental planning. Because of reduced field data gathering time and of state-wide coverage map inspection is quite cost effective. Maps of growth areas are revised each five years keeping them up to date. Present and future land uses are influenced by natural environmental factors derivable from these maps. Existing use as classified by the U. S. Geol. Survey can be determined for most of Level I and some of Level II. Future use can depend on landforms, drain age, geographic aspect, restricted use, transportation network, recreation, & growth direction factors. Landforms can have gentle, steep, or dissected slopes. Drainage divides and floodplains are important for construction and pollution studies. North-facing slopes are usually cooler and wetter with south-facing generally hotter and drier. Military reservations and cemeteries denote restricted land-use. Roads, railroads, pipelines, and transmission lines indicate the transportation network. Public-use recreation areas are usually designated. Map names are often historical keys. Terrain conditions influence the siting of communication towers. Geologic information combined with topographic data can be used to locate unstable areas such as debris, fans, landslides, & rockfalls.

THE RICHMOND TRIASSIC BASIN: AN INTEGRATED GEOLOGICAL/GEOPHYSICAL STUDY. Gerald P. Wilkes, David K. Lasch*, Mary T. Stroh*. Va. Div. of Mineral Resources, Charlottesville, Va. 22903

During the summer of 1978 gravity surveys were completed across the Richmond Triassic Basin on US 6, US 60 and US 360 with an additional survey traversing the Deep Run Basin on US 250. All surveys crossed the Triassic sediments nearly perpendicular to their strike. Station spacing was one-quarter mile in the Richmond Basin and 400 feet across the Deep Run Basin. Density values for gravity modeling were obtained from appropriate core, outcrop and quarry samples. Straight-line sections were constructed for each survey. By incorporating gravity data with geologic cross-sections, hypothetical two-dimensional gravity models were constructed.

The study implies that faulting controls the depth to basement within the basins. This is a result of a series of horst and graben blocks. A major fault forms the western border of each basin. The maximum depths found are located in the western portion of each basin. Also, the frequency of large basement faults decreases from north to south. This can be partially verified, on the eastern margin, by past mining activity and elsewhere through existing regional gravity and magnetic data.

Materials Science

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

Fatigue Crack Growth Simulated in Weld Microstructures
D. M. Abel, M. R. Louthan, Jr., R. D. Sisson, Jr., and
R. P. McNitt, College of Engineering, VPI, Blacksburg, VA.

Fatigue crack growth rates in various microstructures simulating regions of the heat affected zone in mild steel welds were determined from tests of compact tension samples. Crack growth occurred during cycling to a constant maximum load thus to an increasing stress intensity, K . Crack lengths were determined from external measurements, heat tinting and compliance calibrations and graphs of crack growth per cycle (da/dn), versus ΔK were developed. Cycling was continued until crack growth caused the applied stress intensity to produce overload failure. Crack growth rates were highest and overload stress intensities were lowest in the base metal thus showing that, in the absence of adverse environmental effects, the heat affected zone of a weld should be less sensitive to fatigue damage than the base metal.

PRELIMINARY ATTEMPTS TO DETERMINE THE AXIAL THERMAL CONDUCTIVITY OF SMALL POLYMER FIBERS. Larry J. Adams and R. E. Barker, Jr., Materials Science Dept., Univ. of Va., Charlottesville, Va. 22901.

Even under ideal circumstances certain difficulties may be encountered in measuring the true thermal conductivity perpendicular to the surface of a polymer film. The difficulties are greatly magnified when it is desired to determine the anisotropic conductivities in a small fiber or thin fibrillous film. However this is a frequently occurring situation and it would be valuable to have a technique capable of overcoming the formidable problems. Among other merits, such a technique would make it possible to determine the axial conductivities $K_{||}$ of small amounts of newly synthesized fibrous materials. Such a technique also would have important theoretical implications with regard to the effect of fiber size relative to dominant phonon wavelength. For these and related reasons we are investigating methods that may make possible the determination of $K_{||}$ and K_{\perp} for small fibers. (Funded by Airforce Office of Scientific Research, Grant No. AFOSR-80-0014)

THE MELTING TEMPERATURE OF TIN MICROCRYSTALS EMBEDDED IN CARBON. G. L. Allen*, W. W. Gile, and W. A. Jesser, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901.

In the TEM study of the melting point of small metal particles in the size range 10 to 60nm, it is important to limit specimen oxidation. A popular method is to deposit specimens in situ in ultra high vacuum. An alternative method involves deposition of metal particles between two layers of an amorphous carbon "sandwich." This allows the specimen to be transferred in air with minimal oxidation.

Experimental results employing the latter technique show a bulk melting point elevation of about 12°C for tin crystallites. For the model of an elastically constrained specimen enclosed in a bulk matrix, an elevation of about 8°C is calculated from thermodynamic considerations. Equivalent results are calculated for the alternate model of a crystalline metal sphere surrounded by a continuous inert shell. As long as the metal-to-carbon bond is strong, these models predict a melting point elevation regardless of the sign of the particle volume change on melting. (Financial aid by the Army Research Office is gratefully acknowledged.)

HELIUM ION PRODUCED BLISTERING & EXFOLIATION PHENOMENA IN 316 STAINLESS STEEL. James Bennetch and W. A. Jesser, Materials Science Dept., Univ. of Va., Charlottesville, Va. 22901.

Helium ion induced blistering and exfoliation (at 80keV ion energy) of annealed 316 type stainless steel were produced in-situ inside an HVEM. In these HVEM studies, blister caps are defined as being domed in contrast to exfoliation caps, which are flat. Experimental variables included irradiation temperature (up to ~650°C), ion flux (up to $2 \times 10^{15} \text{ cm}^{-2} \text{ sec}^{-1}$) and ion dose (up to $4 \times 10^{18} \text{ cm}^{-2}$). In addition, some irradiated specimens were subsequently annealed at 900°C for ~1 hour in a high vacuum to produce blister caps. A number of new significant observations concerning these two types of events were recorded. First, the ratio of the radii of curvature, R , of blister caps to their diameters, D , was found to be a constant ($R/D = 3.3$) independent of temperature and cap diameter. A critical lateral stress, σ_{crit} , for blister cap formation was calculated: at 650°C, $\sigma_{crit} = 790 \text{ Pa} (115 \text{ kpsi}) = 4.8 \sigma_{y(650^\circ \text{C})}$. In addition, no sudden large scale coalescence of bubbles prior to blister formation was observed; instead, the diameter of bubbles under a blister cap area grew as $(n.t)^{3/4}$ at 650°C, where n = dose and t = time. Finally, a calculation of the number of ions that could be contained in equilibrium bubbles under each type of cap revealed that blister cap bubbles were probably overpressurized. (Research sponsored by Office of Fusion Energy)

TECHNIQUES FOR THE MEASUREMENT OF THE AXIAL ELECTRICAL CONDUCTIVITY OF POLYMER FIBERS. D. Y. Chen* and R. E. Barker, Jr., Materials Science Dept., Univ. of Va., Charlottesville, VA. 22901.

Certain evidence indicates that an extended chain ("rod-like") polymer, such as a polybenzobisthiazole, will have a larger electrical conductivity along its chain direction than along other directions. Efforts to study electrical anisotropy in fibers and fibrilose films often encounter extreme difficulties when the level of conductivity is low. Many factors contribute to the difficulty, among them: the small cross-section of a fiber, electrostatic shielding, electrode contacts, etc. In this paper, a number of techniques for determining the anisotropic electrical properties are discussed. Furthermore there is an intrinsic importance in techniques capable of yielding values for the transport properties of small fibers. (Funded by Airforce Office of Scientific Research, Grant No. AFOSR-80-0014)

Hydrogen Effects on the Flow Characteristics of Austenitic Stainless Steels D. L. DeHart, M. R. Louthan, Jr., R. P. McNitt and R. D. Sisson, Jr., College of Engineering, VPI, Blacksburg, VA.

The flow curve of austenitic stainless steels in the region of uniform plastic deformation can be expressed by the Ludwik model, $\sigma = K\epsilon^n$. The yield and ultimate stresses and ductility of many austenitic steels are affected by hydrogen, thus it was expected that the strain hardening exponent could be affected by hydrogen exposure. This work has shown that the effects of hydrogen on the flow curve are dependent on composition of the steel. An 18-8 steel with low carbon (308) was shown to have the strain hardening exponent and ductility decreased by hydrogen exposure. A 25-20 steel containing high carbon (310), exhibited no hydrogen induced change in the mechanical behavior. These results are discussed in terms of hydrogen effects on the micro-plasticity of austenitic stainless steels.

MEASUREMENT OF ROTOR TEMPERATURE DURING ELECTRICAL BRUSH TESTING. S. A. Dillich, C. M. Adkins, and D. Kuhlmann-Wilsdorf, Dept. of Materials Science, Univ. of Va., Charlottesville, VA. 22901.

A novel method for measuring the temperature of rotating or moving machinery parts has been developed and tested. A temperature measurement assembly was used inside a brush testing chamber for the accurate measurement of slip ring (rotor) temperatures during silver graphite (50/142, 75 w/o Ag 25 w/o C) electric brush tests. Additionally, a new simple method of cooling brushes during testing was devised consisting of a squirrel cage fan rigidly connected to the rotor. The efficiency of the new cooling system was evaluated using rotor temperature measurements during brush testing. It was observed that silver graphite brushes displayed reduced electrical losses apparently as a unique function of rotor temperature. Analysis of the data suggests that the film resistance at the interface is controlled by a Cu_2O layer which exhibits electrical resistance behavior characteristic of a semiconductor with an energy gap for intrinsic current conduction of 1.7 eV. (Funded by Office of Naval Research, Arlington, Va.)

Stress Corrosion Cracking and Hydrogen Embrittlement of Type 310 Stainless Steel C. L. Greene, R. D. Sisson, Jr., R. P. McNitt and M. R. Louthan, Jr., College of Engineering, VPI, Blacksburg, VA.

Stress corrosion cracking in austenitic stainless steels in MgCl_2 solution has been proposed to be either a hydrogen embrittlement phenomena or an anodic dissolution process. Type 310 stainless steel is both embrittled by hydrogen and susceptible to stress corrosion cracking, thus a series of tests were conducted to determine in precharging with high pressure gaseous hydrogen would increase the susceptibility to stress corrosion. Time-to-failure versus applied stress data were collected for wire samples tested on $\text{MgCl}_2\text{-H}_2\text{O}$ solutions boiling at 150°C. Hydrogen pre-charging altered the time-to-failure data thus supporting the hypothesis that hydrogen uptake plays a major role in stress corrosion processes.

THE MECHANISM OF NEUTRON IRRADIATION ENRICHMENT OF LIGHT WATER REACTOR VESSEL STEELS. O. Hodgins and B. Shriver, Dept. of Nuclear Engineering and Engineering Physics, Univ. of Va., Charlottesville, Va. 22901.

The exposure reacted pressure vessel steels to fast neutrons is known to result in reduced ductility and increase the possibility of brittle fracture. Due to safety considerations, limits are placed on the operation of nuclear power plants in order to ensure that brittle failure of the reactor vessel does not occur.

This study will provide data to help elucidate the mechanism of neutron embrittlement and the effects of variations in the irradiation environment, such as neutron flux and irradiation temperature. Both representative steels and simple model alloys, such as Fe-Cu-C , will be considered. To better determine the mechanism of embrittlement, microscopic analyses will be used. These analyses will include electron microscopy, low angle neutron and gamma scattering techniques and x-ray micro-analysis.

The research project and results to date will be discussed. This work is supported by the Electric Power Research Institute.

Storage of Hydrogen in LaNi_5 B. Lewis, J. Murali, R. P. McNitt, R. D. Sisson and M. R. Louthan, Jr., College of Engineering, VPI, Blacksburg, VA.

The use of hydrogen in energy storage systems is currently under extensive study due to the abundance and accessibility of hydrogenous compounds. Practical means of storing hydrogen include the reaction of hydrogen with a metal or alloy to produce a hydrogen saturated "hydride" phase. Certain metallic compounds readily absorb quantities of hydrogen which exceed the amount of hydrogen which could be stored in an equivalent volume as either solid or liquid hydrogen. Thus, energy can be efficiently and compactly stored in the metal lattice. An experimental investigation of the absorption and desorption characteristics of hydrogen from LaNi_5 was conducted. The basic theory associated with the hydriding phenomenon is summarized, and the performance characteristics of LaNi_5 during successive hydriding/dehydriding experiments are presented and compared with typical data already published for this particular alloy.

THE LOCATION OF ZN IN DENTAL AMALGAM. Manuel C. Mejia and Dr. L.B. Johnson. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Previous work has shown that a very small amount of Zn, 3 to 5 atonic percent, has great effect on the physical properties of dental amalgam. For example, the addition of 5 atonic percent Zn to Ag₃Sn increased the compressive strength by about three times and decreased creep by about the same amount.

It was believed that the Zn was located in a strategic position to have such a large effect. This research was undertaken in an effort to determine the specific location of the Zn.

Cylindrical samples 8 mm long and 4 mm in diameter were prepared according to ADA specifications. The alloy used contained 71% Ag, 24% Sn, and 5% Zn. The specimen were polished with SiC paper down to 600 grit and with diamond paste down to 1/4 micron particles. The samples were coated with vapor-deposited carbon and observed in the SEM.

Secondary electron imaging (SEI) and backscattered electron imaging (BEI) in conjunction with energy dispersive X-ray analysis were used to localize the Zn. Two types of SEM's and X-ray analyzers were used to cross-check the results.

It was concluded that the Zn occurred in almost elemental form at the boundaries between the δ_1 (Ag₂Hg₃) and δ_2 (Sn₈Hg) phases.

PRELIMINARY INVESTIGATION OF THE HIGH-TEMPERATURE STRENGTH CHARACTERISTICS OF POLYCRYSTALLINE STEEL WHISKERS ALLOYED WITH CHROMIUM. Thomas M. Moore* and H. G. F. Wilsdorf, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901.

Steel polycrystalline whiskers (Schladitz Whiskers) are high-strength fibers produced by Chemical Vapor Deposition from the thermal decomposition of iron carbonyl in an applied magnetic field. These whiskers are characterized by a primary grain size on the order of 100Å and tensile strength of up to 8 GPa (1.2 Mpsi). A process has been developed for alloying the whiskers during growth with chromium over the entire composition range. The hardness of these alloyed whiskers after a brief heat treatment characteristic of that involved in incorporation of these fibers into a metal matrix composite was studied. A definite resistance to softening was observed but at a higher chromium composition than expected. Also, insights into the whisker growth process were obtained. (This work was supported by a grant from the Office of Naval Research)

Use of Metal Hydrides as a Heat Pump S. M. Milkovich, M. R. Louthan, Jr., R. D. Sisson, Jr. and R. P. McNitt, College of Engineering, VPI, Blacksburg, VA.

Metal hydrides have the ability to absorb and release large quantities of hydrogen many times without significant deterioration. When a metal hydride absorbs hydrogen, the resulting reaction is exothermic. In turn, when the hydrogen is given off, the de-hydrogenating reaction is endothermic. By coupling the exothermic and endothermic reactions and repeating them in cycles, an effective heat pump can be developed. The thermodynamic and kinetic properties of these reactions were studied and used to develop the design of a workable heat pump.

Solubility and Diffusivity of Hydrogen in AISI 1015 Steel J. Murali, Burt Holmes, M. R. Louthan, Jr., R. D. Sisson, Jr., and R. P. McNitt, College of Engineering, VPI, Blacksburg, VA.

The solubility and diffusivity of hydrogen in 1015 steel were investigated. Both gaseous and electrolytic hydrogen charging techniques were used to expose sample membranes approximately 0.04 cm thick and 7 cm in diameter. In the gas phase charging experiments the sample membranes were exposed to purified hydrogen at various pressures for times long enough to cause saturation. Hydrogen outgassing parameters were then measured by sensitive electrochemical techniques. The electrolytic hydrogen charging measurements were made during the rise to and decline from steady state permeation experiments conducted at various input current densities. The results are compared to the literature data and show the effect of trapping on the solubility and diffusivity of hydrogen. Correlations between electrolytic charging measurements and gas phase hydrogen exposures are also presented.

ANALYSIS OF COMPOSITION PROFILES WITH A TIME DEPENDENT SURFACE CONCENTRATION. V. B. Rao and C. R. Houska, Dept. of Materials Engr., Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

An approximate iterative solution has been used to determine composition dependent diffusion coefficients of one-dimensional diffusion zones with a time varying surface composition. It was found that the surface composition could be described by a simple exponential function of time for the Al-Ti system. The composition profile was obtained from an analysis of the (101) α -Ti X-ray diffraction intensity band. Diffusion zones extending from a few tenths to several microns have been examined.

MODIFICATIONS IN THE X-RAY LINE SHAPE ANALYSIS. T. M. Smith* and C. R. Houska. Materials Engineering Dept., Va. Polytechnic Inst., Blacksburg, VA. 24060

Previous papers simplified the Warren-Averbach line-shape analysis by fitting a Fourier series with five parameters to a pair of x-ray diffraction peaks. Further modification of the line-shape analysis for thin films is presented here, which develops a Fourier integral with five separable Fourier coefficients. One can obtain particle size, uniform and nonuniform column strains from a pair of peaks. Also, two instrumental broadening coefficients per peak are used so that a very accurate representation of the instrumental broadening is obtained. A Gauss-Legendre quadrature is used to evaluate the theoretical function which is fitted to the experimental data by a least-squares analysis. A computer program written in FORTRAN IV performs the analysis. When used on the IBM 370 Computer System the computation time is reduced by a factor greater than 100 when compared to the previous Fourier series analysis. The analysis has been performed on 1- μ m thick Mo films on (111) Si single crystal substrates.

EFFECT OF ZINC CONTENT ON FLUORIDE INCORPORATION IN DENTAL AMALGAM. A. Y. Teng and L. B. Johnson, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Five Ag-Sn alloys near the Ag₃Sn composition were chosen as basic materials to which to add zinc in increments of 1, 3, 5, and 7 atomic percent. The alloys were prepared by splat cooling and grounded to -400 mesh powders. These powders were treated with boiling HF for either 5 or 10 minutes, washed and dried at body temperature. They were then analyzed for fluoride content.

The technique for fluoride analysis consisted basically of trapping the fluoride into solution by microdiffusion, followed by quantitative analysis using the fluoride ion-selective electrode.

The amount of fluoride retained by the alloys appeared to depend on alloy composition, the HF treatment time and the extent of washing after the treatment. (Funded by USPHS grant DE 03965.)

Effect of Hydrogen Environments on the Age Hardening Characteristics of 2024 Al J. Wagner, M. R. Louthan, Jr., R. D. Sisson, Jr. and R. P. McNitt, College of Engineering, VPI, Blacksburg, VA.

Aluminum samples were overaged at elevated temperatures in the presence of air and hydrogen - for times ranging from one to eight days. The results of tests done in air environments yielded a tight scatter band of decreasing hardness with increasing aging time. The air exposure data are easily reproduced. Tests conducted in a hydrogen environment produced hardness values with large scatter in comparison with the tests conducted in air. It is believed that scatter obtained in tests done in hydrogen was a result of varying levels of moisture content present in the test environment. The moisture reacts with the aluminum to form Al₂O₃ and hydrogen which is subsequently absorbed in the metal lattice. Hydrogen interacts with the θ phase changing the precipitation reaction and thus changing the aging characteristics of the alloy.

Hydrogen Effects on a Nitrogen Strengthened Steel R. C. Wasielewski, R. P. McNitt, R. D. Sisson, Jr., and M. R. Louthan, Jr., College of Engineering, VPI, Blacksburg, VA.

Hydrogen effects on the notch tensile properties of nitrogen strengthened (21Cr, 6Ni, 9Mn) stainless steel were determined. High temperature thermal charging of hydrogen caused a reaction between the nitrogen in the steel and hydrogen resulting in the formation of ammonia gas. Thus the apparent hydrogen induced effects on the notch tensile properties of a 21-6-9 steel can result from actual hydrogen effects, nitrogen losses during hydrogen charging of internal ammonia formation. The latter two possible interactions are not considered in the interpretation of most of the hydrogen effects data presented in the current literature. Therefore many of the conclusions reached by previous investigators may be erroneous.

Medical Sciences

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

ACUTE TOXICITY OF PHENYLCYCLOHEX-1-ENE IN RATS AND MICE, B.A. Bagshaw¹, V.M. Moser², B.R. Martin, A.E. Munson and L.S. Harris. Dept. of Pharmacology, Med. Col. of VA, Richmond, VA 23298.

Phencyclohex-1-ene (PC) is a pyrolysis product of phenacyclidine (PCP), a drug frequently abused by smoking. Our objective was to determine whether or not PC contributed significantly to PCP's toxicity and obtain baseline toxicity data on PC. Charles River CD-1 mice (22-32 g) were injected with either PC or PCP (prepared in 2.5% emulphor in saline) and observed for 14 days. PCP was more toxic than

LD₅₀ (C.L.) in Mice (μmoles/kg)

	I.V.	I.P.	P.O.
PCP (Males)	57(53-61)	230(208-253)	284(244-330)
PCP (Females)	76(68-84)	292(264-323)	342(287-408)
PC (Males)	448(428-468)	1580(1280-1930)	>9500
PC (Females)	425(415-435)	1570(1250-1980)	>9500

PC in both males and females, regardless of the route of administration. Mice died immediately after i.v. administration of either PC and PCP, whereas mice died predominately within 3 hrs. of PCP (i.p.) and 3 days of PC (i.p.). CD-1 rats (250-310 g) were injected i.v. with PC and the LD₅₀'s for PC in males and females were 415(393-438) and 441(422-472) μmoles/kg, respectively. It appears that the pyrolysis product of PCP has less acute toxicity than PCP in both mice and rats. Supported by grants DA-00490 and 1T32ES07087

PROSTAGLANDIN D₂: ITS DEPRESSANT ACTION AND INVOLVEMENT WITH SEROTONIN, Baxter, C.E., G.A. Patrick* and L.S. Harris Dept. of Pharmacology, Med. Col. of Va, Richmond, Va. 23298

Prostaglandin D₂ (PGD₂) has been shown to possess sedative properties and to produce alterations in EEG recordings when administered to cats, monkeys and rats. PGD₂ has been shown to significantly potentiate pentobarbital sleeping time in mice when administered in the lateral ventricle or intravenously. Sleeping time was measured as the time between injection of PGD₂ and the mouse's regaining of the righting reflex. Serotonin's role in PGD₂ increase of pentobarbital sleeping time was examined. Parachlorophenylalanine a tyrosine hydroxylase inhibitor, significantly reduced by 55% PGD₂'s potentiating effect. 5-Hydroxytryptophan, a serotonin precursor, significantly enhanced the potentiating effect of PGD₂ from 39.5±4.0 minutes to 51.3±7.2 minutes. A toxin specific for serotonergic neurons, 5,7-dihydroxytryptamine (5,7-DHT), decreased PGD₂'s enhancement of pentobarbital sleeping time by 78%. Quipazine, a serotonin receptor stimulant, also decreased the effect of PGD₂. The animals with PGD₂ and pentobarbital slept for 41.5±2.4 minutes while those with quipazine added in addition to the other two slept for 32.3±4.5 minutes. These findings seem to implicate serotonin in the role of PGD₂ as a possible endogenous sedative agent, and suggest that the synthesis rate of serotonin may be the important determinant in modulating PGD₂'s action. (Supported in part by grant #DA-00490.)

THE EMOTIONALLY DISTURBED CHILD: AN ELECTROPHORETIC AND PSYCHOLOGICAL CORRELATIVE STUDY. E.R. Berry, A.J. Finch* and W. Draper*. Departments of Anatomy and Psychiatry, Medical College of Virginia, Richmond, Virginia 23298

Serum samples by finger puncture were obtained from 15 patients at admission to the Virginia Treatment Center for children. Six of the patients were followed for the duration of their stay by samples at intervals of about 10 days for this "double blind" study. Micro-agar gel electrophoresis (Wieme) was utilized with Oil Red O as the lipid-protein stain and Buffalo Black for protein. Mathematical analysis for the composite tracings was by the interval method (Berry et al.). Case history and evaluation of each child was made by the Center staff. Correlation of withdrawal, hyperactivity and prognosis with the electrophoretic status was by Stalling's rho test.

The data of three patients followed in depth: one sub-clinical hypothyroid, a sub-clinical hyper thyroid, and a euthyroid child are presented. The T-3 binding pre-albumin involved in surgical "stress" (Surks and Openheimer) with the a₂ "stress" pattern (Berry et al.) are illustrated. A three dimensional plot of the admission data is discussed.

THE SOLUBLE EPITHELIAL PROTEINS IN THE GLAUCOMATOUS RABBIT CORNEA. E.R. Berry, T.M. Harris*, L.B. Sheppard*. Department of Anatomy, Medical College of Virginia, Richmond, Virginia 23298.

Corneal epithelium, scraped from the eye, was frozen and lyophilized.

Dry weight was determined, water added, 20 ul/mg, homogenized, centrifuged to clear the supernate and a 2 ul sample used for electrophoresis by the micro method of Wieme. Glycoprotein was determined by PAS staining. Protein, determined by Buffalo Black.

Normal epithelial tissue was from Ax/J and glaucomatous tissue from Ax/bu/J Jackson lab rabbits.

Differences between the genetic lines are: soluble protein, glycoprotein content and type, pre-albumin content and distribution, "albumin" content, and proclonal type.

Biochemical individuality, lack of bi-lateral symmetry in the eye pairs, and the lability of the glycoprotein are presented.

D-LACTATE FORMATION IN HUMAN BLOOD. R. B. Brande. Dept. of Biochemistry, Med. Col. of Va., VCU, Richmond, VA 23298.

Methylglyoxal (MeG) has a potential role in control of cell growth. Metabolism of MeG to D-lactate (not the L-lactate of glycolysis) is catalyzed by the mammalian enzymes glyoxalase I (6-lactyl-glutathione methylglyoxal lyase, isomerizing; EC 4.4.1.5) and glyoxalase II (S-2 hydroxyacyl glutathione hydrolase; EC 3.1.2.6), with glutathione as a coenzyme. Determination of MeG in tissues is difficult, due to the active glyoxalase system. However, the product, D-lactate, indicates formed or added MeG. A stereospecific assay was used for plasma D-lactate involving spectrophotometric analysis of NADH at 340 nm catalyzed by D-lactic dehydrogenase. Blood collected by venipuncture was used to determine plasma D-lactate concentration. The mean D-lactate plasma concentration for seven normal subjects was 0.023 mM, 0.002 SEM. When the glycolytic pathway in whole blood was inhibited *in vitro* with fluoride, a significant increase in D-lactate was found (about 0.15 mM/hour at 37°). Added MeG gave a proportional increase in D-lactate concentration. Some specific precursors of L-lactate (dihydroxyacetonephosphate for example) added to whole blood increased the formation of D-lactate, even when glycolysis was not inhibited. This finding indicates that catabolites of glucose lead to MeG synthesis and suggests a control function for the glyoxalase enzyme system in glycolysis that may be exploited for cancer therapy. (This research was supported by funds from the National Foundation for Cancer Research.)

CHEMICAL CHARACTERIZATION OF NUCLEAR ENVELOPE PEPTIDES: A COMPARISON OF TRYPTIC PEPTIDE MAPS. D.L. Cochran and K.R. Shelton, Dept. of Biochemistry, Med. Col. of Va., Richmond, Virginia 23298

The insolubility of membrane proteins has plagued attempts to characterize this class of proteins by classical chemical methods. Nuclear envelope proteins have been no exception. By combining several recently developed methods we have obtained two-dimensional tryptic peptide maps of three nuclear envelope polypeptides. These predominant polypeptides in the avian erythrocyte nuclear envelope fraction have been isolated by a method combining isoelectric focusing in one dimension and sodium dodecyl sulfate polyacrylamide gel electrophoresis in the second dimension. Gel sections containing individual polypeptides were cut out and the polypeptides labeled with 125 I by the chloramine-T method, digested with trypsin overnight and spotted on cellulose thin layer plates. Chromatography was performed in the first dimension, the plates dried, and then electrophoresis performed in the second dimension. Fluorography was used to locate polypeptides on the plates. Of the three major polypeptides examined two share many spots while the third reveals a unique pattern. These results are consistent with the *in vitro* demonstration that two of the polypeptides are related by a cleavage process. (Work supported by grant #CA15923, NCI, DHEW).

EFFECTS OF PROTEIN INTAKE AND EXERCISE ON ABSORPTION SPECTRA SCANS OF BLOOD PLASMA FROM YOUNG MEN. G. Colmano, S. S. Edwards, N. L. Marable. Col. Veterinary Medicine and Dept. Human Nutr. & Foods*, VPI & SU, Blacksburg, VA 24061

Since Greek times, athletes as part of their training, have consumed excessive amounts of meat protein in the belief that it would replace their spent muscle. In this context, the effects of a progressive resistance exercise program in young men fed the Recommended Daily Allowance of protein (RDA=0.8g/Kg body wt/day) or three times the RDA (2.4g/Kg body wt/day) were investigated. In order to study protein metabolism in humans, the current trend has been to rely on body composition, urinary nitrogen, creatinine, total serum protein, hematocrit, hemoglobin, and usual hematological indexes. These measurements were taken but did not adequately reflect the protein turnover of the body in response to exercise. In animals, three major protein chromophore absorbances at 196nm, 278nm, 414nm, respectively for dipeptide bonds, aromatic amino acid residues, and hemoproteins, were detected spectrophotometrically and their concentrations were related to protein utilization. In the human subjects the absorbances of these chromophores were related to the metabolic protein status obtained by the accepted methods. The results from the normal and high protein intake groups under exercise indicated a lower urinary nitrogen relative to intake nitrogen. The spectrophotometric absorbances not only confirmed the results but also described changes in the concentration of the components of the three protein chromophores.

COMPARISON OF 260-280 nm ABSORPTION SPECTRA, LOWRY, AND BIURET DETERMINATIONS ON BSA STANDARDS AND BLOOD PLASMA. G. Colmano and S. S. Edwards. Div. Veterinary Biol., Col. Veterinary Medicine, VPI & SU, Blacksburg, VA 24061

Tryptophan, tyrosine, phenylalanine, histidine, and cystine have a common ultraviolet absorbance at 240nm, depending on amino acid components. As histidine and cystine have a low molar absorbance, the major contributions of tryptophan: tyrosine:phenylalanine, at 27:8:1, have absorption maxima at 280nm, 275nm, and 258nm. The resultant absorption at 278nm, because of the constant concentration in proteins of the above amino acids, reflects the concentration of protein in blood plasma and serum, and is very close to 1 mg of protein/ml for a spectrophotometric absorbance of 1 at 278nm. The ultraviolet 280nm absorbance has been used extensively for protein estimation in enzyme purification when the 260nm absorbance of nucleic acid was lower than the 280nm absorbance of the protein, which purity and concentration was then calculated on a 260/280nm nomograph, correcting for possible nucleic acid contamination. Because unfractionated blood plasma nucleic acid concentration does not contribute at 260 nm, the 280nm absorbance alone was used in dilutions (1:10, 1:200, 1:5000, which followed Lambert-Beer's Law for protein concentration, initially determined by the Lowry methods, which was not proportional to concentration, but had been described to be more accurate than the Biuret. Our Biuret and Lowry determinations confirmed previous findings, however, our linearity at 278nm for protein concentration in blood plasma has proven superior.

GLUCOCEREBROSIDES: THEIR PROPERTIES IN LIPID BILAYERS. M.C. de la Feire, * Dept. of Biochemistry, Univ. of Va., Charlottesville, VA 22904

Glucocerebroside (Glc-Cer) is a simple glycosphingolipid and is found on the external surface of plasma membranes. In patients with Gaucher's Disease, Glc-Cer accumulates in reticulum endothelial cells and forms filament-like structures. We are interested in studying the properties and structure of Glc-Cer and its effect on the structure and properties of phospholipid bilayer systems. Small unilamellar sonicated vesicles and multilamellar liposomes were used as bilayer membranes systems. Glc-Cer can only be incorporated into these vesicles up to 20 mole %. Anthroyl-low and pyrene labelled Glc-Cer were synthesized and incorporated into bilayers to measure the kinetics and phase separation in the phospholipid bilayer. The rate of exchange of Glc-Cer can be calculated by pyrene excimer formation and by 3 H-Glc-Cer exchange between vesicles. The rate of Glc-Cer movement was slow. Calorimetric data suggests that above 10 mole % Glc-Cer forms patches in the phospholipid matrix. These results suggest that the behavior of Glc-Cer *in vitro* mimics its behavior *in vivo*. We postulate that as the Glc-Cer concentration *in vivo* is increased, the amount that the cell incorporates into its membrane is limited. Glc-Cer rich domains on the cell surface can be formed followed by a drastic precipitation of excess Glc-Cer into the cytoplasm producing the Gaucher Glc-Cer filaments. (Aided by NIH Grant GM 23573.)

Vascular Response to Acute Hypertensive Insult in the Cat. D.S. Dewitt, R.L. Hayes, J.T. Povlishock, D.P. Becker. Depts. of Neurosurgery & Anatomy, Medical College of Virginia, Richmond, Virginia 23298.

Acute hypertensive Insult (HI) has been reported to cause the formation of lesions in feline cerebral vascular endothelium. This study was undertaken to investigate the temporal sequence of the genesis and resolution of such lesions. Cats were rendered hypertensive by the infusion of norepinephrine, and perfused 2, 10, 30 minutes and 4 and 8 hours after the onset of the HI. The brains were removed and samples were taken from cerebral cortex, diencephalon, brain stem and cerebral arterioles. The brain parenchymal samples were sectioned and, along with bisected pial arterioles, were processed for scanning electron microscopy. The luminal surfaces of the intraparenchymal vessels contained within the sections and the luminal surfaces of the pial arterioles were viewed and photographed on a scanning electron microscope. Lesions were counted from these micrographs. Endothelial balloons and craters appeared as early as 2 minutes after HI and were present in increasing numbers at 10 and 30 minutes. By the fourth hour after insult, the number of lesions had significantly decreased and by 8 hours, although there was no further significant decrease in the number of lesions, the lesions remaining appeared to be resolving as they were less conspicuous. These data suggest that acute HI initiates immediate endothelial damage which progresses and after several hours, begins to resolve. Supported by NIH Grant NS-12587.

The EPG, mass photoreceptive potentials from a VERTEBRATE (frog: *Rana esculenta*). Clark S. Donley and Hilmar Meisler¹—The Collegiate Schools and The Max Planck Institute, Richmond, Va. 23229 & Bad Nauheim, Germany

The pineal organ of the lower vertebrates is directly photosensitive. In the frog an extracranial portion (stinorgan) provides wavelength ("color") information while an intracranial portion (epiphysis) provides intensity information to an as yet undetermined location for an as yet undetermined function. The epiphysis produces a potential (EPG) analogous to the ERG of the more usual lateral eye. That the EPG reflects mainly massed receptor activity is evidenced by the lack of a knee in the dark adaptation curve, the dominance of the potential by the scotopic component even under photopic light conditions, the limited number of neural cells in the organ, and some preliminary chemical studies.

The EPG consists of a rapid (less than 1 second) photic component responding best at longer wavelength, and a slower scotopic response responding best at about 500 nm. The EPG dark adapts about 3.5 log units over about an hour and a half, light adapts again over about 30 minutes and shows the remarkably long integration time of about 5 seconds in the dark adapted state. The direct availability of such photoreceptive potentials without the use of intracellular recording or special chemical isolation suggests the use of the preparation for such things as chemical screening of receptor active drugs.

ESSENTIAL AREAS AND MECHANISMS OF MORPHINE ANTINOCICEPTION IN RODENTS. T.C. FU, S.P. Halenda, W.L. Dewey. Dept. of Pharmacology, Med. Col. of Va., Richmond, Va. 23298

The essential areas for morphine antinociception and their mechanisms were studied in the decerebrate and in the lightly anesthetized mice and rats. The antinociception was quantitated by the tail-flick response. Several techniques have been used, including: (1) precerebral decerebration, (2) anemic decerebration, (3) vertebral artery infusion, (4) cross-circulation, (5) spinal ligation, (6) spinalization with dura mater intact, and (7) spinal subarachnoid infusion. Morphine antinociception was abolished or greatly reduced by percolular transection or by anemic decerebration in mice but not in rats. Analgesia cannot be induced by a dose of 5mg/kg morphine directly perfused into forebrain region via common carotid artery; however, it can be initiated by a much lower dose (0.5mg/kg) of morphine infused via vertebral artery. Spinal ligation abolished morphine induced antinociception in both mice and rats. Spinalization with dura mater intact eliminated the antinociceptive effect of morphine in rats but not in mice. Tail-flick response can be effectively inhibited by subarachnoid infusion of morphine at the level of T₁₃ in mice and rats. However, (D-Ala)²-(des-COOH-Nle)⁶-enkephalin is over 300 times (ED₅₀=0.015µg) more potent than morphine at the lower spinal level in mice, but in rats up to 150 times dose the ED₅₀ in mice produced no analgesia. From these findings it is concluded that the areas and pathways involved in the mechanism of morphine antinociception are different in the mouse from the rat. (Aided by NIH grant DA016477)

CHEMOTAXIS OF AVIAN EMBRYONIC BLOOD CELLS BY ORGAN CULTURE SUPERNATANTS. K.L. Holmes and J.L. Haas¹, Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298

Blood borne hemopoietic stem cells (HSC), presumably arising from the yolk sac (YS), are first seen in the chicken bursa of Fabricius (BF) on the 10th day of gestation followed by the appearance of increasing numbers of HSC's between days 12 and 14. Several investigators have suggested that a BF chemotactic factor may exist that selectively attracts HSC's. This theory was tested using blind well chemotactic chambers. The ability of embryonic (11-14d) organ culture supernatants (SUP) of BF, liver and kidney to attract YS cells of the same ages was compared with media controls. YS cell suspensions were centrifuged on a BSA gradient and cells banding between the 33% and 23% fractions were removed for use in blind wells. YS cells were placed in the upper chamber and separated from either supernatant or control media below by a 5 µm Nucleopore polycarbonate membrane. The liver SUP generally had higher than control migration at all ages tested while the BF wells at 11 and 12 days failed to show even control level migration, but increased to above control on days 13 and 14. The rise of migratory activity between days 12 and 13 days in the BF wells corresponds to the influx of HSC's in the BF seen *in vivo*. Migration of YS cells to the liver SUP's suggests the possibility of a hemopoietic function in that organ, contrary to recent reports. Electron microscopic observation of 124 fetal liver indicates that it does contain HSC's.

IDENTIFICATION OF PHENYLCYCLOHEX-1-ENE, A PYROLYSIS PRODUCT OF PHENYLCICLIDINE IN SMOKE. A.S. FREEMAN¹, B.R. MARTIN and L.S. Harris. Dept. of Pharmacology, Med. Col. of Va., Richmond, Va. 23298

Parsley cigarettes (55 mm, 550 mg) were machine rolled and injected uniformly, 10 mm from each end, with ethanolic solutions of ³H-phenylcyclidine (PCP). A simple smoking apparatus was designed to smoke the cigarettes and trap the smoke on glass wool filters. The filters were washed with chloroform and the extract assayed for radioactivity. Of the radioactivity (0.5 µCi) injected into cigarettes containing 3, 10, 30, and 50 mg of PCP-HCl, 76%, 84%, 70%, and 42%, respectively, was recovered from the filters. In order to quantitate ³H-PCP and identify pyrolysis products, each chloroform extract (150 µl) of the glass wool was applied to two thin-layer plates as a band along with 10 µg of PCP and phenylcyclohex-1-ene (PC). One plate was developed in chloroform (90 ml): methanol (10 ml): conc. ammonia (4 drops) in which PC had an R_f of 1.0 and PCP had an R_f of 0.5. The other plate was developed in hexanes (5 ml): conc. ammonia (1 drop) in which PC had an R_f of 0.5 and PCP remained at the origin. In both TLC systems, 48% of the recovered material was associated with PCP and 48% with PC. Samples were also analysed using GC-MS. A calibration curve was constructed using standard solutions of PCP and PC. Single-ion monitoring of their respective base peaks showed that approximately equivalent quantities of PCP and PC were present in the smoke condensates. (Supported by NIDA Grant DA-00490)

PREFRONTAL PROJECTIONS TO THE CENTRAL GYRUS IN THE MONKEY: AN ORTHOGRADE AND RETROGRADE HRP STUDY. S.G.P. Hardy¹ and G.R. Leichnetz². Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298.

The central gyrus (CG) is a structure to which many functions have been attributed, including analgesia, aversion and reward. In order to assess the potential influence that the cortex may exert upon this structure a study was made of the cortical efferents to CG in the monkey using the horseradish peroxidase (HRP) technique. In a series of cynomolgus (*Macaca fascicularis*) and capuchin (*Cebus albifrons*) monkeys, HRP gel placements were made in various subregions of the prefrontal cortex, and stereotaxic HRP fluid injections (0.01 µl 25% HRP in sterile saline) were made into the CG. Gel placement cases were used to study orthograde transport and fluid injection cases were studied with regard to retrograde transport. After survival periods of 24-48 hrs. the monkeys were processed according to the tetramethylbenzidine protocol (Mesulam, 1978) and sections were studied under bright and dark field microscopy. Results from this study indicate that the prefrontal cortex projects significantly to the CG, whereas few cortical areas outside the frontal region are involved. The prefrontal-CG projection arises primarily from small lamina V pyramids in the medial prefrontal cortex and dorsal convexity. Other areas of the prefrontal cortex also contributed projections of a lesser extent to the CG, with the exception of the medial orbital cortex.

BLOOD-BRAIN BARRIER DYSFUNCTION FOLLOWING CEREBRAL ISCHEMIA. L. W. Jenkins¹, J.T. Povlishock², and D.P. Becker³, Depts. of Neurosurgery and Anatomy, Med. Col. of Va., Richmond, Va. 23298

Sites of blood-brain barrier (BBB) dysfunction assessed by increased permeability to horseradish peroxidase (HRP) were correlated with neuronal alterations as evaluated by morphological analyses in adult rats subjected to complete cerebral ischemia (CCI). All animals were subjected to 5-8 min. of CCI of which a limited number were perfusion fixed immediately after the insult. The remaining animals were perfused after variable periods of post-ischemic recirculation of up to an hour. HRP was injected either immediately preceding the insult or after periods of recirculation. Subsequent to perfusion fixation consistent brain segments from all animals were subjected to vibratome sectioning and reacted for HRP visualization. In those animals perfused immediately after CCI no increase in BBB permeability to HRP was seen and a homogeneous population of neuronal alterations was observed. However, in animals with recirculation, focal HRP leakage was noted across numerous vascular segments. Concomitant with such leakage, the homogeneous neuronal perturbations seen immediately following CCI were modified into a heterogeneous pattern of more severe neuronal alterations in sites displaying BBB dysfunction. Such an observation suggests that BBB dysfunction may be related to the maturation of neuronal injury seen during the recirculation period following cerebral ischemia. (Aided by NIH grant NS-12587)

CHANGES IN PITUITARY SENSITIVITY TO LH-RH AT PUBERTY: EVENTS OF THE INITIAL PROESTRUS. J.H. Johnson, Dept. of Anatomy, Medical College of Virginia, Richmond, Virginia 23298.

Pituitary responsiveness to pulse injections of LH-RH shows no dramatic change in prepubertal rats until the afternoon of the first proestrus. The present study was undertaken on the premise that use of a constant rate infusion of LH-RH might reveal responses not observed in previous studies. Groups of rats were studied between the ages of 36 and 43 days. Phenobarbital was injected at noon to eliminate endogenous LH-RH release. Beginning at 14:00, blood samples were obtained at half hour intervals during the 3-hour period when LH-RH was infused at 50 ng/hr through a double-lumen jugular cannula implanted 1 day earlier. Vaginal opening occurred at proestrus or estrus on days 41-43. The peak level of circulating LH was significantly greater at age 42 than at 36, 38, 40 or 43. Responses at other ages were not statistically different from one another. However, the peak LH response was most significantly correlated with the stage of the estrous cycle: that observed at proestrus was greater than those of diestrous, estrous or anestrus (prepubertal) animals. These results fail to suggest an essential role of altered pituitary responsiveness in the onset of puberty. Rather, in agreement with the results of previous investigators, they reflect events at the initial proestrus, indicating that cyclic mechanisms have already been set in motion. (Supported by NIH Grant HD 11247)

DYNAMICS OF CYTOCHROME b_5 -MEMBRANE INTERACTIONS. T.L. Leto, *Dept. of Biochemistry, Univ. of Va. Sch. of Med. Charlottesville, Va. 22908.

Cytochrome b_5 (cyt b_5) is an integral membrane protein found in high concentrations on the endoplasmic reticulum in liver and is involved in unsaturated fatty acid biosynthesis. Cyt b_5 is the first integral membrane protein to demonstrate exchangeability between membrane structures in vitro. Fluorescence methods have been used to study the binding of cyt b_5 to membranes, intermembranous exchange of cyt b_5 , and the topology of cyt b_5 -membrane complexes. Enhancement of cyt b_5 tryptophan fluorescence occurs upon association of this protein with a variety of membrane preparations. The binding of cyt b_5 to membrane preparations derived from brominated phospholipids results in a quenching of cyt b_5 fluorescence. These observations indicate that binding involves an association of cyt b_5 with the hydrophobic core of the membrane. The kinetics of cyt b_5 intermembranous exchange between the quenching and enhancing membranes has been followed directly from the observed protein fluorescence. Suitable controls have ruled out the possible occurrence of significant exchange of lipids or fusion of membranes to account for the fluorescence changes. Based on these kinetic studies we propose that exchange of cyt b_5 is due to the existence of a free aqueous form of cyt b_5 which is in equilibrium with the membrane bound species. (Supported by NIH grants GM 23258 & ST32 CA 09109)

THE RESPONSE OF THE RETRACTOR BULBI MUSCLES TO OXYMETHOXY NERVE STIMULATION IN THE CAT M.A. Meredith* and S.J. Goldberg*, Dept. of Anat., Med. Col. Va., Richmond, Va. 23298

Recent studies have suggested that a small population of retractor bulbi (RB) motoneurons (MN) are located within the oculomotor (OC) nucleus. The present experiments were conducted to establish the presence of RB axons within the OC nerve and to determine their distribution to the RB muscle. In the orbit, the RB muscles were cut from their insertions and attached to tension transducers. A bipolar steel electrode was used to stimulate the OC nerve in the brainstem. OC nerve branches to the superior rectus, medial rectus, inferior rectus, and inferior oblique muscles were cut and the contralateral abducens (AB) nerve and nucleus were lesioned. Contractions of the RB muscles produced by OC nerve stimulation were characterized by faster contraction times, faster half-decay times, and weaker whole muscle tensions than reported for responses elicited by AB nerve stimulation. The response of the RB muscles varied between individual cats and an estimated 0-15 RB MNs project to motor units in each muscle slip.

These results confirm the presence of RB axons in the OC nerve, possibly distinguishing those RB motor units from units controlled by the AB nerve, and suggest a role of the RB muscles in patterned eye movements.

(Aided by USPHS grant EY-01442)

EFFECT OF HALOPERIDOL ON SPONTANEOUS LUTEINIZING HORMONE RELEASE AND SUBSEQUENT OVULATION IN THE RAT. Richard J. Krieg Jr., and James H. Johnson, Department of Anatomy, Med. Col. of Va.-Va. Com. Univ., Richmond, Va. 23298.

The capability of haloperidol (H) to block dopaminergic inhibition of prolactin (PRL) release at the pituitary level is well established. The present studies were designed to investigate the effect of H on luteinizing hormone (LH) release and ovulation in normally cycling proestrous rats. Doses of 0.125, 0.25, 0.5, and 1.0 mg/kg of H were administered sc. in corn oil at 1330 h. Blood samples were taken via intra-atrial catheter immediately prior to injection, and at two hour intervals from 1430 to 2230 h. Animals were checked for ovulation on the next morning. A significant release of PRL occurred within one hour after injection of all doses of H except 0.125 mg/kg. The proestrous surge of LH was not blocked by any of the doses of H and ovulation was observed in 5/8 (1.0 mg/kg), 4/7 (0.5 mg/kg), 4/7 (0.25 mg/kg), and 5/5 (1.0 mg/kg) animals. These data show that afternoon administration of H does not block LH release or ovulation at the doses presently used. This stands in contrast to other studies in which similar doses of H were shown to block ovulation if injected at 0930 h (Neuroendocrinology 15: 10-20, 1974). Further experiments are in progress to explain whether this difference is due to a direct effect of H, or a secondary effect (such as PRL release) which blocks ovulation only if it occurs well in advance of the LH surge. (Supported by NSF grant #ECM7922155, and NIH grants HD1247 and HD12165).

MESOIONIC HETEROCYCLES AS INHIBITORS OF C-AMP PHOSPHODIESTERASE. Julie Macdonough, Drs. JD Smith, RA Glennon*, ME Rogers; Dept. of Pharm. Chem., MCV-VCU, Richmond, 23298.

Phosphodiesterases (PDE) are a group of enzymes which regulate intracellular levels of cyclic nucleotides. For example, cyclic AMP PDE catalyzes the hydrolysis of c-AMP. Theophylline, a 1,3-dimethylxanthine, is a known competitive inhibitor of PDE. Structural modifications of the xanthine have led to more potent and selective inhibitors. A previously synthesized series of mesoionic xanthine analogs revealed theophylline-like activity as PDE inhibitors. In order to further investigate structure-activity relationships and in an attempt to optimize activity, it was of interest to synthesize analogs with various substituents on the original mesoionic purine analog. We also prepared examples of several ring systems where the 5-membered ring has been replaced by a pyridine, pyrimidine, or isoquinoline moiety. The target compounds were synthesized via a thermal condensation of a bis(2,4,6-trichlorophenyl) malonate ester with the appropriately substituted alkylaminoheterocycle. The latter was prepared either through an acylation-reduction or by a DiMroth rearrangement. The compounds were tested for PDE inhibition using the Klee Assay, and the results will be more fully discussed in the following paper. Briefly, as inhibitors of cyclic AMP PDE, the activities of the mesoionic compounds (IC_{50} values) ranged from 50-2000 μ M, compared to 300 μ M for Theophylline.

HEMODYNAMICS, HYPOGLYCEMIA AND HEPATO-PANCREATIC PATHOLOGY DURING THE COURSE OF ENDOTOXIN SHOCK. N.H. Manson*, T.H. Wendel*, L.R. Eaton*, and M.L. Hess. Depts. of Physiology and Medicine. Med. Col. of Va., Richmond, Va. 23298

The interrelationship between hemodynamics and hypoglycemia during the course of Endotoxin Shock (ES) has not been fully defined. In the following study, ES (E. coli, 1 mg/kg; n=7) was induced in a canine model and systemic hemodynamics, glucose metabolism, and hepatic and pancreatic function monitored for 5 hrs. and compared to Time Matched Controls (TMC; n=4). Total Peripheral Resistance (TPR, dynes-sec-cm⁻⁵) increased from 3227 \pm 430 to 4050 \pm 750 at 10 min and then declined to 3050 \pm 1100. At 90 min, TPR progressively increased to 6225 \pm 749 by 5 hrs. Plasma glucose did not significantly differ from control values (105 \pm 4 mg%) for the first 90 min but then declined to 78 \pm 2 mg% at 5 hrs. (TMC = 98 \pm 4, p<0.05). Serum amylase during the 5 hr. protocol was not elevated (TMC = 110.9 \pm 2.4; ES = 100 \pm 1.97% p<0.01) and light microscopy of the exocrine pancreas demonstrated normal acinar structure. In contrast, islet cell structure from the ES group demonstrated clumping and disruption not seen in the TMC. Hepatic histology in the ES group demonstrated periportal and peribulbar degeneration and hepatocyte disruption not seen in the TMC. It is hypothesized that ES results in a circle of positive feedback initiated by an increase in TPR and subsequent decrease in flow resulting in hepatopancreatic ischemia with preferential islet cell disruption producing, in part, the hypoglycemia of ES. (Aided by NIH grant HL 24502-01)

PHOSPHOLIPID DISTRIBUTIONS IN LARGE UNILAMELLAR VESICLES. J.R. Nordlund*. Dept. of Biochemistry, Univ. of Virginia School of Medicine, Charlottesville, Virginia 22908.

Membranes regulate cellular activities by compartmentalizing cellular functions. Compelling evidence exists which supports the notion that membrane constituents are asymmetrically distributed. The tendency of phospholipids to form asymmetric bilayers has been examined in unilamellar vesicles of various diameters. The distribution of egg phosphatidylethanolamine (PE) in large unilamellar egg phosphatidylcholine (PC)-egg (PE) vesicles was determined by 2,4,6-trinitrobenzenesulfonic acid labeling. These vesicles were obtained by modifying the ethanol injection procedure described by Batzri and Korn, using a slow injection rate. After injection the ethanol was removed and the vesicles were centrifuged. This resulted in a homogeneous, large and unilamellar vesicle population as determined by column chromatography and ^{31}P NMR. PE in vesicles of 10, 30, and 50 mole percent PE was found to be equally distributed between the two monolayers. In contrast, PE in PE-PC small unilamellar vesicles formed by rapid ethanol injection was preferentially localized in the outer monolayer at low PE concentrations and in the inner monolayer at high PE concentrations. These results suggest that while phospholipids may spontaneously form asymmetric bilayers in highly curved regions of biological membranes, other factors must be responsible for phospholipid asymmetry in general. (Aided by USPHS, NIH grants GM-14628 and GM-23573.)

HISTOLOGICAL CHANGES IN RAT HEARTS AFTER SINGLE EPISODES OF FORCED EXERCISE. S. Ramundo*, Dept. of Physiol., Med. Col. of Va., Richmond, Va. 23298; M. Persinger* and M. Alkhan*, Laurentian Univ., Sudbury, Ontario, Canada.

Groups of young and old rats were exposed to a single episode of either forced running: 1, 6, 12 or 24 hr duration, or to sedentary conditions for similar durations. Both young and old rats demonstrated highly significant increases in cardiac weight ($F(3,46)=16.01$, $p<.01$) and body weight loss ($F(3,46)=9.83$, $p<.001$) as a function of exercise duration. Animals subjected to the same treatments but allowed to recuperate for 24 hr showed some reversal of these effects. Chi-square analysis of the 4 run times with the two age groups and histological ratings indicated a significant effect ($\chi^2(12)=35.7$, $p<.001$) for the basal level of the heart. No significant differences for other areas of the heart or between ages were evident. Histological data, as compared to controls, indicate the following: (1) the majority of fuchsinophilia and necrosis occurred within the base of the left ventricle, especially within the subendocardium; (2) the degree of "waviness" within muscle bundles and of the width of interfiber space increased with exercise duration. These studies indicate that acute maintained exercise can produce histological changes indicative of myocardial degeneration and necrosis, as well as cardiac edema. This rapid process of cardiac edema appears to be somewhat reversible if the stressor is removed and the animals allowed to recuperate for a period of 24 hr, although histological changes remain.

BRAIN REGION AND SUBCELLULAR DISTRIBUTION OF RADIOACTIVITY IN MICE AFTER ACUTE ADMINISTRATION OF ^{14}C -POLYCHLORINATED BIPHENYLS. D.L. Rosin*, B.R. Martin and G.A. Patrick*. Dept. of Pharmacology, Med. Col. of Va., Richmond, VA. 23298

Previous studies in our lab have shown that polychlorinated biphenyls (PCBs) alter central neurotransmitter function *in vitro* at concentrations of 10^{-5} to 10^{-4} M and depress spontaneous motor activity of mice after an oral dose of 500 mg/kg. Radiolabeled PCBs were added to *in vitro* systems and administered orally to determine tissue levels and distribution in brain. Mice were administered an oral dose of PCBs of 500 mg/kg containing 2-4 μCi ^{14}C -PCBs and were decapitated at various times. Brain, liver and plasma levels of radioactivity were measured at 0.25, 0.5, 0.75, 1, 2, 4, and 8 hrs after gavage. Levels increased up to 2 hrs then reached a plateau. The 0.75 and 2 hr time points were chosen for studying distribution in brain areas and subcellular fractions of whole brain. Radioactivity was distributed evenly in 6 brain areas at both time points with levels about 3 times higher at 2 hrs than at 0.75 hr. In subcellular fractionation of brains, the largest proportion of radioactivity was distributed to myelin, synaptosomal, and microsomal fractions. Levels observed in these fractions following oral administration were comparable to those which altered central neurotransmitter function *in vitro*. (Supported in part by EPA Grant R-806481 and NIH Training Grant GM-07111)

STUDIES ON HOST VERSUS GRAFT SYNDROME. G.H. O'Neal, Sue S. Gross*, J. J. Ruffolo*, and R. Hard*. Depts. of Biophysics and Pathology Med. Col. of Va., Richmond, VA. 23298

Experimental Host Versus Graft Syndrome (HVG) is a fatal complex of lesions which may follow the perinatal inoculation of (T6 x RFM)F₁ hybrid spleen cells into a related RFM strain mouse. HVG mice usually die in 30 days of membranous glomerulonephropathy from deposition of immune complexes. Other pathologic changes include (T-) immunodeficiency, hyperimmunoglobulinemia, liver and renal lesions, plasmacytosis and under some conditions, tumors of the lymphatic system and liver. IgG levels of the HVG mice may be elevated 30-70 times control values. IgA and IgM appeared early in the syndrome followed by rapid increases in all serum Ig levels. IgG₁ and IgG₂ declined in the last stage of the disease and IgM levels were above the adult maximum. Murine leukemia virus has been isolated from both parental types, the F₁ and the HVG animal. The F₁ virus has been shown to be a typical ecotropic MuLV by morphological, immunological and physical criteria. A mouse tropic virus has been isolated from the HVG animal. In a preliminary study on a tumor from the liver of a G3H mouse, virus can be easily seen. Characterization of the various viral isolates is underway. Serum protein patterns of the two parental strains, the F₁ animal and the HVG animal exhibit qualitative differences. (Supported by ACS Grant IM-125)

DIFFERENTIATION OF PRE-B CELLS IS INDUCED BY HYBRIDIZATION WITH MYELOMA CELLS. S.C. Riley*, E. J. Brock*, and W. M. Kuehl*. Dept. of Microbiology, Univ. of Va., Charlottesville, Va. 22908

Murine pre-B cells, which express cytoplasmic μ heavy chain but no L chain, are the progenitor cells of surface Ig⁺ B lymphocytes. An Abelson murine leukemia virus transformed lymphoid mouse cell line (18-81) has pre-B cell characteristics. 18-81 was fused with myeloma cell lines in an attempt to induce the next step in pre-B cell differentiation, i.e. L chain expression. 40% of somatic hybrids between 18-81 (μ^+ , L⁻) and a variant myeloma cell ($\gamma 2a^+$, L⁻) express a κ L chain which is not produced by either of the parents. The κ L chain expressed in the pre-B cell x myeloma hybrids is coded for by the pre-B cell genome. The L chains expressed by independent 18-81 x myeloma hybrids are also shown to be different by peptide mapping. (Aided by NIH Grant AI 12505-05).

RESPONSIVENESS OF THE PAT AORTA AND FEMORAL ARTERY TO EPINEPHRINE AND HISTAMINE DURING PREGNANCY. R. F. Sisson, III* and J. L. Hart. Dept. of Biology, George Mason Univ., Fairfax, VA. 22030

The responsiveness of isolated arteries to epinephrine (E) and histamine (H) before and at two times during pregnancy (8-12 days and 18-22 days) were compared. Helically cut aortic strips (A) (6-10mm x 2mm) and femoral artery cyclinders (FA) (4-6mm long) from 2-3 month old SD rats were suspended in 30ml oxygenated Krebs-filled baths at 37°C. Isometric tension was recorded while cumulative dose-response curves to both E and H were done on each tissue. Mean (\pm SE) maximum tension (mg tension/mg tissue weight) (contractility) is listed in the Table ($n=6-7$ at each time). Although contractility was greater, especially during mid-pregnancy, for both arteries in response to both E and H, ANOVA indicated that none of these changes was significant ($p > .05$). These results do not support previous studies that have reported decreases in responsiveness of blood vessels to some vasoactive agents during pregnancy. (Supported by GMU Grant #5-25012 and NSF Grant DEB 79-05841.)

	MAXIMUM TENSION	
	Non-preg	8-12 day pregnant
Epinephrine		
A	205 \pm 36	301 \pm 11
FA	300 \pm 62	409 \pm 45
Histamine		
A	124 \pm 13	220 \pm 33
FA	92 \pm 14	155 \pm 25
		116 \pm 24

CONFORMATIONAL DOMAIN STRUCTURE IN PHOSPHATIDYLCHOLINE-CHOLESTEROL AND SPHINGOMYELIN-CHOLESTEROL MIXTURES. B. Snyder*, Dept. of Biochemistry, University of Virginia, Charlottesville, Va. 22908

The lateral organization of cholesterol in phospholipid bilayers has been investigated through a method of Monte Carlo calculations using interaction energies deduced from calorimetric results for cholesterol-phospholipid mixtures. Analysis of computer generated bilayer configurations allows calculation of the spatial localization and relative abundance of distinct regions of varying cholesterol content along the plane of the bilayer. The results indicate that the degree of nonideality in the mixing of cholesterol is dependent on the fatty acid chain lengths of the phospholipid and that cholesterol mixes more ideally in sphingomyelins than in phosphatidylcholines of equal chain length. It is found that at ≈ 20 mole % cholesterol those membrane regions which are rich in cholesterol suddenly become connected forming a network which extends over the entire bilayer. This change in the lateral connectivity of the cholesterol rich domains occurs over a very narrow concentration range and is accompanied by a parallel decrease in the connectivity of the free lipid domains. This long range connectedness transition is presumably responsible for the abrupt change in the lateral diffusion coefficient and the sharp decrease in the ability for protein incorporation observed at this concentration. (Supported by NIH grants GM-27244 and GM-26894).

EVALUATION OF A SERIES OF MESOIONIC XANTHINE ANALOGS AS PHOSPHODIESTERASE INHIBITORS. Sheree L. Thomas*, Michael E. Rogers*, Richard A. Glennon*, J. Doyle Smith. Dept. of Pharm. Chem., Med. Col. of Va., Richmond, Va. 23298

Methylated xanthines, such as theophylline inhibit cyclic nucleotide phosphodiesterases, an effect that may be responsible for their clinical utility. Because of the close structural similarity, mesoionic xanthine analogs are capable of inhibiting phosphodiesterase. The purpose of this research was to evaluate a series of mesoionic xanthine analogs for their ability to inhibit bovine heart cyclic AMP phosphodiesterase. A radiolabeled assay was used as previously described. In brief, tritiated cyclic AMP was incubated with bovine heart phosphodiesterase in the presence and absence of inhibitors. The product, 5'-AMP, was isolated via chromatography using an ion exchange resin and was quantitated using liquid scintillation counting. The I_{50} values were determined by plotting uninhibited velocity/inhibited velocity (Vo/V) versus the inhibitor concentration. The I_{50} is the inhibitor concentration when Vo/V = 2. Five different inhibitor concentrations, giving 25-75% inhibition, were used for each inhibitor. Fifteen new mesoionic compounds were examined including three new ring systems. Structure activity relationships for these compounds indicate that variation of groups on the ring system significantly influences inhibitor activity, the mesoionic six-membered ring is necessary for good activity, and variation of the non-mesoionic five-membered ring can lead to compounds with enhanced activity as inhibitors.

EFFECTS OF ANTINOICEPTIVE DOSES OF OXOTREMORINE ON CHOLINERGIC SYSTEMS OF THE MOUSE BRAIN. H.L. Tripathi*, F.J. Vocci* and W.L. Dewey, Department of Pharmacology, Med. Col. of Va., Richmond, Va. 23298

We have studied the effects of antinoiceptive doses of oxotremorine on the levels of acetylcholine (ACh) choline (Ch) and turnover rate of ACh in whole mouse brain following two methods of sacrifice, decapitation and microwave irradiation. Antinoiceptive activity in mice was determined by the tail-flick method (6 mice/gp) and effective doses ED₅₀ (9.0ug/kg) ED₅₀ (13.0ug/kg), and ED₅₀ (20.0ug/kg) were determined by the method of Litchfield and Wilcoxon. These doses were administered subcutaneously and ACh levels were determined at 15, 30, 45 and 60 min. intervals. The ED₅₀ dose showed a significant increase in ACh levels at 15 and 30 min. intervals by both methods. The turnover rate of ACh and Ch levels were determined 20 min. after drug administration. A dose dependent decrease was found in turnover rate of ACh. The ACh turnover rate decreased from 11.06 \pm 1.62 n mol/g/min. to 5.38 \pm 0.71 n mol/g/min. by the decapitation method and 30.20 \pm 1.8 n mol/g/min. to 19.99 \pm 1.6 n mol/g/min. by the microwave irradiation method. A significant increase in Ch levels was found by the ED₅₀ dose of oxotremorine by microwave irradiation method but not by the decapitation method. Significantly lower values of ACh, Ch and ACh turnover rate were found in decapitated animals as compared to microwave irradiated mice. (Supported by USPHS DA-00326, DA-07027 and DA-00490).

MODULATION OF IMMUNOCOMPETENCE IN MICE DURING DMH-INDUCED COLORECTAL CARCINOGENESIS. A.K. Szakal, B.A. Divan*, and K.E. Blackman*, Dept. of Anatomy, Med. Coll. Va., Richmond, Va. 23298 and Life Sciences Div.*, Melyo Labs, Inc. Springfield, Va. 22151.

A tri-phasic modulation of immunocompetence was demonstrated in 1,2-dimethylhydrazine (DMH) treated SWH/T mice in a correlative study utilizing mitogenic stimulation of T and B lymphocytes, histological parameters of lymphoid tissue immune responses, and colorectal tumor development.

In phase I, a depression of the regional and an enhancement of the systemic immunocompetence initiated by DMH preceded the development of the initial colorectal lesions. In phase II, an enhanced regional and systemic immunity, as well as an extensive splenic myeloid metaplasia corresponded to morphogenetic changes in the colorectal epithelium representing a transition from hyperplasia to neoplasia. In phase III, a reduction in both regional and systemic immunocompetence was associated with the growth of adenocarcinomas. Systemic immunity, as indicated by the continued depression of mitogen reactivity and the depletion of the splenic white pulp was abrogated concomitantly with the increase in tumor burden. Regional immunity, however, recovered and became enhanced simultaneously with the appearance of invasive adenocarcinomas.

The observed modulation represents a dynamic tumor-host interaction favoring colorectal tumor development.

DESIGN AND SYNTHESIS OF IRREVERSIBLE PHOSPHODIESTERASE INHIBITORS. K.A. Walker and M.E. Rogers, Dept. of Pharmacology, Med. Col. of Va., Richmond, Va. 23298

Cyclic adenosine monophosphate (cAMP) has been shown to regulate or influence a wide range of physiological functions. Intracellular levels of cAMP are regulated primarily by the cyclases which catalyze its synthesis and by phosphodiesterase (PDE) which catalyzes its degradation. PDE is not a simple molecular entity, but a complex enzyme system existing in multiple molecular forms. Differing molecular forms of PDE are unique to each tissue, and even to each cell type. Selective inhibition of different PDE isozymes would make it possible to raise cAMP levels in discrete cell types, thereby manipulating specific biological processes.

By preparing an inhibitor with maximum affinity for an enzyme and incorporating an alkylating function capable of forming a covalent bond, an active-site directed irreversible inhibitor is achieved and a further degree of selectivity is available. Although papaverine is one of the most potent known PDE inhibitors it is also one of the least specific. Modifications on the papaverine molecule involving introduction of an alkylating moiety could enhance its specificity and result in irreversible inhibition of PDE. A series of 6,7-dimethoxy-1-phenylisoquinolines have been synthesized to investigate the irreversible inhibition of PDE.

THE GLOXALASE SYSTEM IN THE GROWING RAT. M. G. Waters*, R. B. Brandt, D. J. Muron*, M. H. Bloch*. Dept. of Biochemistry, Med. Col. of Va., VCU, Richmond, Va. 23298

The 3-carbon keto-aldehyde, methylglyoxal (MeG), has been shown to inhibit growth in bacterial and mammalian systems. The glyoxalase enzyme system catalyzes the cytotoxic α - β -dicarbonyl to form D-lactate in the presence of glutathione (GSH). Glyoxalase I (S-lactoyl-glutathione methylglyoxal lyase, isomerizing; EC 4.4.1.5) and glyoxalase II (S-2-hydroxyacyl glutathione hydrolase; EC 3.1.2.6) are ubiquitous in mammalian tissues and have a high specific activity in red blood cells. In order to determine possible changes in the glyoxalase system with growth, the various components of the glyoxalase system were measured in the blood of male Sprague-Dawley rats aged 20 to 135 days. Glyoxalase I and II activity and kinetic parameters were determined in phosphate buffer. Glutathione reductase activity, blood concentration of GSH and protein, plasma concentration of D-lactate, and hematocrit were also measured. The glyoxalase II catalysis of S-lactoyl-glutathione (SLG) to D-lactate is the rate determining step in the catabolism of MeG in blood. The V_{max} for the reaction was 42 μ moles/min/ml RBC as compared to 82 μ moles/min/ml RBC for glyoxalase I. The K_m values for MeG and SLG were 0.9 mM and 1.2 mM respectively. The K_m and V_{max} for the glyoxalase reactions were found not to be age dependent in the first 4 months of life. (This research was supported by funds from the National Foundation for Cancer Research.)

STREPTOZOTOCIN (STZ) INDUCED CHANGES IN RAT LIVER TRIGLYCERIDE (TG) CONTENT AND GLYCEROLIPID BIOSYNTHESIS. Judith A. Woods* and Robert G. Lamb. Departments of Pharmacology and Medicine, Medical College of Virginia, Richmond, Virginia 23298.

Diabetes (STZ-induced) rapidly increases rat serum and liver TG content and hepatic TG synthesis. These diabetic dependent changes in the level and formation of TG are related to alterations in insulin levels since they are reversed by insulin administration.

The STZ-dependent rise in hepatic TG formation is partially explained by an increase in the activity of enzymes (phosphatidate phosphohydrolase and GP acyltransferase) regulating the incorporation of sn-[1,3-¹⁴C]glycerol-3-P(GP) into TG. Diabetes induced increases in liver TG biosynthesis and enzyme activity are associated with alterations in serum factors since hepatocytes and hepatocyte monolayers exhibit an increased capacity to incorporate GP into TG following exposure (1-18 hr) to serum isolated from diabetic animals compared to control serum. The importance of serum factors was also supported by the observation that hepatocyte monolayers exposed to a mixture of control serum and serum components (glucagon, oleate, glucose and ketones) elevated by diabetes, exhibited increases in TG formation which were identical to those produced by diabetic serum. Hepatocytes exposed to individual agents (ketones>oleate>glucagon>glucose) also showed a rise in TG biosynthesis; however, a mixture of agents always initiated a greater response. (Supported by NIH grants AM 18976 and 21924).

THE RELATIONSHIP BETWEEN SURFACE AND SECRETED IgG_{2a} IN MOUSE LYMPHOMAS. C. J. Word* and W. M. Kuehl*. Dept. of Microbiology, Univ. of Va. Sch. of Med., Charlottesville, Va. 22908

A spontaneous Balb/c murine B-lymphoma, A20, expresses immunoglobulin (Ig), Fc receptors and Ia antigens on its cell surface, but no complement receptors, thus representing an intermediate in the differentiation scheme of B-cells. Biosynthetic cell labeling reveals that A20 synthesizes two species of intracellular γ_{2a} heavy (H) chains with molecular weights of 62,000 and 68,000 daltons, each of which is associated with κ light chains. Secreted IgG_{2a} contains γ_{2a} H chains of 64,000 daltons while surface IgG_{2a} contains 70,000 dalton γ_{2a} H chains. Fusion of A20 to a terminally differentiated murine myeloma results in a hybrid expressing a more differentiated phenotype for the A20 IgG_{2a}. Synthesis of the secreted form of the lymphoma IgG_{2a} is amplified 10-100 fold but the surface form of the lymphoma IgG_{2a} is no longer expressed in the hybrid. The data suggest that the 62,000 dalton intracellular γ_{2a} H chain is the precursor to the secreted IgG_{2a}, while the 68,000 dalton intracellular γ_{2a} H chain is the precursor to the surface IgG_{2a}. Peptide map analysis indicates that the two intracellular γ_{2a} H chains have identical methionine-containing peptides and may be coded for by the same γ_{2a} H chain gene. (Supported by NIH Grant AI 12525-05).

Microbiology

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

UTILIZATION OF PEPTIDES BY *NEUROSPORA CRASSA* AS A SOLE SOURCE OF NITROGEN. J. Castellano and L. Wolfenbarger, Jr., Department of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Peptides ranging in size from a mean number of residues of 30 down to dipeptides support growth of a leucine auxotroph when used as both a nitrogen and leucine source. Under nitrogen limiting conditions the peptides "induce" extracellular peptidohydrolytic activity which hydrolyzes the peptides to monomer amino acids. Growth of leu-2 on those peptides transportable by the oligopeptide transport system does not result in "induction" of hydrolytic activity whereas growth of leu-2; *glt-r*, which lacks a transport system, results in induction of peptidohydrolytic activity on these same peptides.

INACTIVATION OF POLIOVIRUS-2 IN NATURAL WATERS: A THERMOSTABLE FACTOR. J.C. Johnson, R.P. Olson*, and P.G. Haggerty*, Dept. of Biological Sciences, ODU, Norfolk, VA. 23508.

The inactivation of a plaque-purified poliovirus-2 in natural fresh and marine surface waters obtained from South-eastern Virginia was found to be biphasic with the initial inactivation rate at 17°C six to ten-fold greater than the secondary rate. Most (70 to 90%) of the inactivation occurred during the initial rapid phase and was found by sedimentation studies to be related to the amount of virus aggregates. Using an assay for proteolysis which measured the mobility and dispersity of polypeptides by means of polyacrylamide gel electrophoresis in the presence of sodium dodecyl sulfate, ¹²⁵I labelled bovine serum albumin was found to be nearly 50% hydrolyzed after 25 days of incubation in filter sterilized marine surface water at 17°C. Similarly, ¹⁴C-amino acid labelled poliovirus-2 polypeptides VP1, VP2, VP3, and VP4 were found to be extensively degraded in filter sterilized ocean water but not in autoclaved and filter sterilized, deionized or marine water, although in the latter case some degradation was detected. The heat-sensitive proteolytic activity was not isolated nor has it been concentrated. Although it is probable that this heat sensitive activity contributes to virus inactivation in marine water, no direct correlation between the biphasic inactivation rates and the proteolytic activity could be made.

A POTENTIAL MACROREGULATORY MECHANISM FOR GROWTH REGULATION IN *NEUROSPORA CRASSA*. M. Mooney* and L. Wolfenbarger, Jr., Department of Biological Sciences, Old Dominion University, Norfolk, VA 23508

Neurospora produces a phase specific cationic mucopolysaccharide, composed primarily of galactosamine (GAG-MP), which becomes part of the cell wall and is later secreted into the media. Its appearance coincides with the onset of the restricted phase of growth, and causes efflux of small molecular weight metabolites when incubated with conidial cells. This activity may be a product of electrostatic interactions of the GAG-MP with the conidial plasma membrane. The activity is blocked by acetylation of the primary amines on the molecule, digestion by enzymes that hydrolyze carbohydrate linkages and the inclusion of NaCl (1M) in the GAG-MP/conidia reaction mixture. The GAG-MP's physiological activity mimics that of known depolarizing agents. A model is proposed in which GAG-MP depolarizes the plasma membrane at the onset of the restricted phase of growth, stimulating a cell surface enzyme to produce endogenous cAMP which in turn switches on the enzymatic and genetic machinery necessary for that phase of growth. (Aided by Grant from National Foundation March of Dimes)

ANTIBODY ISOTYPE MEDIATED ANTIGEN RETENTION IN PASSIVELY IMMUNIZED MICE. Richard P. Phipps, G.F. Mitchell*, T.E. Mandel*, and J.G. Tew. Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23298 and The Walter and Eliza Hall Inst. of Med. Res., Melbourne, Australia.

Antibody isotypes vary in their capacity to mediate retention of an easily catabolized protein antigen, human serum albumin (HSA), in spleen and popliteal lymph node follicles and collagenous tissues in hind feet. Hyperimmune murine anti-HSA sera were separated into fractions highly enriched for IgM, IgG₁, and IgG₂ via differential elution from staphylococcal protein A-sepharose. Fractions obtained were used to passively immunize normal mice, followed 24 hours later by radioindicated HSA injected into the hind foot pad. The amount of HSA retained in these tissues was determined 6 days later when HSA was localized to lymphoid follicles and collagenous tissues of the hind feet.

The ability of fractions to mediate HSA retention in splenic follicles could be ranked IgG₂ > IgG₁ > IgM. Autoradiography confirmed this localization pattern. In PLN the pattern was similar except that IgM containing fractions mediated HSA retention to a high degree. In tendons of the hind foot, IgG mediated HSA retention 5 times better than IgG₂ or IgM fractions. The amount of radioactivity in the liver varied inversely with HSA retention in other sites. The results show differences in antibody isotype requirements for antigen localization in spleen and PLN follicles and in particular collagenous tissues of the hind foot.

DETERMINANT SPECIFICITY OF ANTICATALYTIC ANTIBODIES SPECIFIC FOR HORSE RADISH PEROXIDASE. R.B. Salter*, D.C. Borzelleca*, and J.M. Conroy. Dept. of Biology, Microbiology Section, Va. Polytechnic Inst., Blacksburg, VA, 24061

Rabbit antisera specific for horseradish peroxidase were fractionated by absorption with altered enzyme forms and other plant peroxidases to determine the nature of the enzyme sites that bind anticytalytic antibody. While apoperoxidase was immunologically identical to the holoenzyme, the S-carboxymethylated (CM) apoenzyme bound only 30-50% of the total antiperoxidase pool. The antibody unreactive with the CM-apoenzyme retained the anticytalytic activity of unfractionated serum. Similar results were obtained when the apoenzyme was reduced and alkylated with iodoacetamide. These results suggest that anticytalytic antibodies recognize conformation dependent antigenic determinants. Antibodies specific for horseradish peroxidase cross reacted extensively with carrot, turnip and radish peroxidases. However, only radish enzyme activity was inhibited by antihorseradish peroxidase sera. Fractionation experiments demonstrated that the determinants recognized by inhibitory antibody are present on the radish enzyme but not on the turnip or carrot enzymes.

Further experiments were performed to determine how inhibitory antibody decreases enzyme catalytic activity. These experiments exploited the distinct absorption spectra of native peroxidase and enzyme intermediate forms. The results obtained suggest that anticytalytic antibody does not prevent the formation of the first enzyme intermediate.

BIOCHEMICAL CHARACTERIZATION OF GLYCEROL KINASE FROM PSEUDOMONAS AERUGINOSA. J.R. Sellers*, L.G. Schirch* and S.M. McCowen. Department of Biology and Department of Biochemistry, Virginia Commonwealth University, Richmond, Virginia 23284

Glycerol kinase has been purified from cells of *Pseudomonas aeruginosa* strain PAO cultured on basal salts medium with glycerol and Casamino Acids as carbon sources. The enzyme was isolated from the 100,000 X g soluble fraction and purified 500-fold by ammonium sulfate precipitation and chromatography on columns of sephadex G-25, DEAE sephadex, hydroxyapatite and sephadex G-200. The enzyme has a molecular weight of approximately 120,000 daltons as estimated by gel filtration.

Kinetic studies indicate that the enzyme phosphorylates glycerol to L-α glycerophosphate by a sequential mechanism. The enzyme exhibited an apparent Km of 10mM for glycerol and 100μM for ATP. Mg²⁺ was required for activity although Mn²⁺ could be substituted with less activity at equal molar concentrations.

ISOLATION, IDENTIFICATION, AND CHARACTERIZATION OF THE FUNGAL FLORA FROM NORMAL AND DIABETIC HUMAN EYES.

R.M. Shaffer*, D.M. Dixon and C.R. Graham, Jr., Dept. of Biology, Loyola Col., Baltimore, MD 21210.

The ocular fungal flora of 23 humans was investigated. Corneas of cadaver donors to the Medical Eye Bank (Baltimore, Maryland) were sampled with sterile cotton swabs prior to removal or disinfection procedures. Swabs were streaked on Sabouraud's and Mycosel agar plates for incubation at 30°C for up to 3 weeks. Eighty-seven percent of the individuals were positive for a total of 42 fungi. Corneas of non-diabetic humans yielded predominantly molds (62%), while corneas of diabetics yielded primarily yeasts (58%). In both groups of people, *Penicillium* and *Cladosporium* species were the most frequently isolated molds. Other hyphomycetes included *Penicillium* spp., *Fusarium* spp., *Paeclioncyces* sp., and *Alternaria alternata*. Isolates of yeasts from non-diabetic corneas included *Trichosporon cutaneum*, *Aureobasidium pullulans*, *Candida parapsilosis*, and *Rhodotorula glutinis*. Yeasts from corneas of diabetics included *A. pullulans*, *B. rubra*, *C. parapsilosis*, and *Cryptococcus laurentii*. Furthermore, twenty-four percent of the fungi were dematiaceous. Forty percent of these failed to liquefy 12% gelatin.

MOLECULAR CHARACTERIZATION OF PLASMIDS DETERMINING COLONIZATION ANTIGENS OF ENTEROTOXIGENIC ESCHERICHIA COLI. T.N. Swanson, A. Allen, P.L. Shipley. Medical College of Virginia, Richmond, VA, 23219

Diarrheal disease caused by enterotoxigenic *E. coli* (ETEC) is mediated by a combination of enterotoxin production and specific adherence to the intestinal epithelium. The K88 surface antigen of *E. coli* is a fimbriate protein of ETEC strains which allows specific adherence to the porcine intestinal epithelium. K88 is an important virulence determinant, and is coded by transmissible bacterial plasmids.

Mating experiments have been performed capitalizing on the fact that the K88 determinant is associated with genes specifying raffinose fermentation (Raf+). The K88 genes are coded by a 50 Mdal plasmid species which is quite homogeneous for all strains examined. A number of conjugative plasmids are able to mobilize K88-Raf plasmids to recipient strains, in particular a 50 Mdal R-factor specifying tetracycline and streptomycin resistance. Mobilization of K88-Raf plasmids by this transfer plasmid is greatly facilitated by the *recA* gene of *E. coli* in donor strains. Transconjugants which contain a 90-100 Mdal cointegrate plasmid are obtained when Raf+ recipients are selected. Restriction enzyme analysis suggests that the two plasmid undergo mutual site-specific recombination at a unique site located within the K88 genetic determinant. Plasmid dissociation within the recipient to the original two 50 Mdal plasmids restores the K88+ phenotype. (Supported by NIH grant AI15586)

HETEROGENEITY IN ANTICATALYTIC ACTIVITY OF ANTIBODIES

SPECIFIC FOR HORSE RADISH PEROXIDASE. M.A. Vick*, R.G.B. Roy*, and J.M. Conroy. Dept. of Biology, Microbiology Section, Va. Polytechnic Inst., Blacksburg, VA, 24061

Rabbit antibodies specific for horseradish peroxidase (HRP) are heterogeneous in their ability to inhibit enzyme activity. Heterogeneity was demonstrated by fractionation of the total antiperoxidase pool into antibody subpopulations that differed in anticytalytic activity. The fractionation procedures used were differential ammonium sulfate precipitation of antisera and differential elution of antiperoxidase from affinity columns containing insolubilized HRP. Some antibody subpopulations decreased catalytic activity almost completely at low molar ratios of antibody to enzyme. Other subpopulations were not efficient inhibitors even at high molar Ab/HRP ratios. Mixing experiments demonstrated that inefficient antibody pools decreased the anticytalytic effect of highly inhibitory antibody. The degree of inhibition observed with unfractionated antiserum is a reflection of the interaction of various antibody subpopulations with the enzyme. No correlation was found between the immunoglobulin class of antiperoxidase and anticytalytic efficiency in analyses of numerous antisera. The inhibitory efficiency of an antiperoxidase molecule is most likely related to its determinant specificity.

Space Science and Technology

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

INVESTIGATION OF THE LEADING-EDGE VORTEX FLAP CONCEPT ON A SLENDER DELTA WING. J. F. Campbell and J. K. Huffman, NASA Langley Res. Ctr., Hampton, Va. 23665 and T. D. Johnson*, Kentron International, Inc., Hampton, Va. 23665.

This paper presents experimental and theoretical results on a leading-edge flap device that induces the formation of a vortex along its length through forced separation that acts on the flap to alter the aerodynamic characteristics of slender wings; thus, the name "vortex flap." Balance measurements were collected during subsonic wind tunnel tests on a 74° delta model with the vortex flap deflected at both down and up angles and in combination with a trailing-edge flap. Lift performance showed dramatic improvement as the vortex flap deflection angle was changed from 45-deg. down to 15-deg. up, and with increasing down-deflection angles of the trailing-edge flap.

The primary feature of the vortex flap concept is the ability to change the direction of the vortex-induced suction force acting on the flap. Deflecting the flap down results in thrust recovery to enhance maneuver performance, whereas, deflecting the flap up results in higher lift for takeoff and landing operations. Vortex flow theory showed good agreement with the experimental data.

VELOCITY MEASUREMENTS BY ION TRACING IN UF₆. S. S. Fisher and M. G. Hodgins*, School of Engr. and Appl. Sci., U. Va., Charlottesville, VA 22901.

An ion-tracing velocity measurement technique applicable to gases is described. With this technique, ions are produced by focusing a high-power pulsed laser in the gas, thereby inducing electrical breakdown. Ion paths and times-of-flight are then determined by means of a small ion-collector probe. This technique has been used to measure flow speeds and Mach numbers in the far-field (rarefied) regions of low-density free-jet expansions of UF₆ from a converging nozzle. A 4 mJ/pulse nitrogen laser is used. Breakdown is induced in the continuum-flow part of the jet, just downstream of the nozzle exit. Flow-speed measurement precision is approximately 1%. The nozzle Reynolds number range from 100 to 14,000 is covered. The advantages of this technique over other velocity-measurement techniques are discussed.

LOW REYNOLDS NUMBER PITOT-PRESSURE MEASUREMENTS IN FREE-JET EXPANSIONS. G. A. Graybeal* and S. S. Fisher, School of Engr. and Appl. Sci., U. Va., Charlottesville, VA 22901.

The use of a Pitot (impact-pressure) probe as a diagnostic device for low-density supersonic flows is discussed. The problem of interest with such probes is that, at low values of the probe Reynolds number (based on tube diameter and incoming flow conditions), measured Pitot pressures exceed those expected on an ideal basis. Apparatus designed to evaluate this effect for supersonic flows of UF₆ is described. In this apparatus, the gas expands from a converging nozzle into a vacuum chamber, thereby forming a supersonic free-jet expansion. To within good approximation, the variation of the ideal Pitot pressure within these jets is known from other data. The Pitot tube is mounted on a mechanism which allows it to be traversed along the orifice axis and also laterally at constant distance from the orifice center. Probe Reynolds number is varied by varying the probe diameter, the position of the probe in the jet, and the flow stagnation pressure. To some extent, Mach number for the flow approaching the probe can also be varied. A co-objective of this study is to use Pitot probes to more accurately establish density-velocity fields for free-jet expansions.

DETERMINATION OF THE STRUCTURAL DEFLECTION INFLUENCE COEFFICIENT MATRIX FOR SOLID WING MODELS. Sudhir C. Mehrotra*, Vigyan Research Associates, Inc., 28 Research Drive, Hampton, VA 23666

The experimental deflection for a transport-type solid wing model were measured for several single-point load conditions. These deflections were compared with those obtained by structural modeling of the wing by using plate and solid elements of Structural Performance Analysis and Redesign (SPAR) program. The solid element representation of the wing showed better agreement with the experimental deflections than the plate representation. The difference between the measured and calculated deflections is about 5 percent.

MINIMUM NOISE IMPACT AIRCRAFT TRAJECTORIES. R. G. Melton* and I. D. Jacobson, Dept. of Mechanical and Aerospace Engineering, Univ. of Va., Charlottesville, Va. 22901

A flight path modification approach has been used to minimize the noise impact to a community in the near terminal area. The measure of noise annoyance used is Noise Impact Index (NII). Two models of the flight path have been investigated: 1) a truncated Fourier series and 2) a small number of linear segments connected by circular arcs. Existing optimization techniques have been employed. The results of a case study at Patrick Henry Airport are presented. (Work supported by NASA Langley Research Center under grant NSG 1509).

EXPERIMENTAL AND THEORETICAL FORCE AND PRESSURE PROFILES IN A SINGLE DRIVER ACOUSTICAL LEVITATOR. John P. Hugley, III,* Dept. of Mech. Engr., Univ. of Va., Charlottesville, Va. 22901

This paper describes a study of phenomena in a single driver acoustical levitator. A levitator was designed and constructed, pressure and force profiles in the levitator were measured, and the experimental results were compared to theoretical predictions. Pressure and force profiles were measured along the vertical centerline of the levitator at sound pressure levels of 140 dB to 154 dB and compared to theoretical predictions. Pressure profiles measured at a sound pressure level of 150 dB showed that a pressure well had developed around the horizontal centerline of the enclosure. The depth of the well and the pressure gradients caused by the well increased with increasing sound pressure level. Levitational forces up to 170×10^{-5} Newtons were measured on a 1 inch diameter, $\frac{1}{4}$ inch thick disk at a sound pressure level of 154 dB. The measured and calculated pressure profiles showed similar trends, but also showed substantial differences in the magnitude of the pressures and pressure gradients, and increasingly poor agreement as the sound pressure level increased. The measured and calculated force profiles at a sound pressure level of 154 dB showed similar trends but the theory generally underpredicted the measured forces by about a factor of three.

AEROELASTIC DIVERGENCE EXPERIMENTS ON FORWARD-SWEPT WINGS. Rodney H. Ricketts*, NASA Langley Research Center, Hampton, Va., 23665.

Recently there has been a renewed interest in using forward-swept wings in airplane designs. To study the aeroelastic instabilities (divergence and flutter) associated with these wings, several models were tested in the 16' Transonic Dynamics Tunnel. Metal plate models were tested at low speeds to determine the effects of sweep angle and aspect ratio. Transonic effects were studied by testing the models to 0.9 Mach number. Airfoil shape effects were determined to be substantial during the testing of three different airfoil contours, namely, flat-plate conventional 64A010, and uncambered supercritical. Aeroelastically tailored composite material models were also tested at transonic speeds. Test results for one model agree very well with linear theory predictions because the model consisted simply of a wing with a very thin airfoil shape. Test results for another model do not agree as favorably. This is attributed to the more complex model configuration which included a wing with a supercritical airfoil shape mounted on a fuselage half-body. To safeguard the models from destruction during the tests, six subcritical response techniques were developed and used to predict the divergence instability before it occurred.

A SURVEY OF SUPERSONIC FLIGHT. M. Leroy Spearman, Aerospace Technologist, Aeronautical Systems Division, NASA Langley Research Center, Hampton, Virginia 23665

Even though manned flight only began early in the 20th Century, studies of flight at speeds in excess of the speed of sound (supersonic) were underway before the end of the first decade of the century. Remarkable progress in the speed of airplanes and missiles has been made during this century, including speeds sufficient to provide for flight into outer space. This paper will provide a survey of the major milestones in the progress of supersonic flight including some of the problems encountered, the solutions developed, the advent of missiles, some airplane programs such as the X-series of flight vehicles, the "century series" fighters, bomber development, multimission airplanes, the commercial transport, and some current programs. The current technology status and the future outlook for supersonic flight will also be reviewed.

STAGED FUEL INJECTION FOR THE LANGLEY SCRAMJET ENGINE. E.H. Weidner*, Hypersonic Propulsion Branch, High-Speed Aero. Div., NASA Langley Research Center, Hampton, VA 23665.

There is an ongoing effort at the NASA Langley Research Center to develop a supersonic combustion ramjet (scramjet) engine that can be used as the propulsion system for hypersonic aircraft. The basic engine is divided into several identical modules each of which consists of an inlet, fuel injection struts, a combustor and a nozzle. Gaseous hydrogen fuel is introduced into the engine from the struts in both parallel and perpendicular directions to the primary flow.

An important analytic contribution to combustor research at Langley has been the development of a computer code which analyzes two dimensionally the flow field near a perpendicular fuel injector. The program solves the elliptic compressible Navier-Stokes and specie equations using a predictor-corrector technique. It predicts the turbulent mixing of fuel and air, and allows the study of separated regions of flow both upstream and downstream of the injector.

Presently, the effects of a staged fuel injection system are being studied using this code. The purpose of staged injection is to produce an interaction of the separated regions between the two injectors, optimizing conditions for flameholding. This paper investigates key parameters such as fuel split and distance between stages.

Statistics

Fifty-Eighth Annual Meeting of the Virginia Academy of Science
May 13-16, 1980, University of Virginia

THE ONE-TAIL, TWO-TAIL DILEMMA IN HYPOTHESIS TESTING. Robert L. Andrews, Inst. of Stat., Va. Commonwealth Univ. Richmond, VA 23284

In teaching hypothesis testing it is no easy matter to give clear guidelines for the student to use to decide if a one-tail test or a two-tail test is the proper procedure. This paper examines this dilemma and some ethical overtones that seem to be involved. In conclusion, a straightforward alternative is presented that evades this entire issue.

THE ESTIMATION OF NONLINEAR SYSTEMS OF EQUATIONS. Oral Capps, Jr., Dept. of Agr. Econ., VPI&SU, Blacksburg, Va. 24061

Many contemporary models of consumer demand comprise complete sets of highly nonlinear demand functions. Consequently, practitioners are continually faced with theoretically satisfactory models imbued with severe practical difficulties. Estimation methods should take into account parameter nonlinearity, cross-equation correlation, variance-covariance singularity of the error terms, and various parameter restrictions. Two potential estimation methods are the maximum likelihood procedure and the seemingly unrelated nonlinear regression procedure. This paper gives a theoretical and empirical comparison of these methods in the estimation of parameters from complete sets of nonlinear demand functions when the error terms are contemporaneously but not serially correlated.

AREA ESTIMATES BY LANDSAT: ARIZONA 1979. M. E. Craig, C. E. Miller. Statistical Research Div., Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture, Washington, D.C. 20250

This report describes how data from NASA earth resources monitoring satellites, LANDSAT II and III, were used in conjunction with conventionally gathered ground data to estimate planted crop areas in the nine southern-most counties in Arizona. Estimates using LANDSAT and ground data jointly were more precise than those obtained utilizing ground information alone. The major emphasis of the project was to improve cotton, sorghum and localized corn area estimates. Availability of LANDSAT data and lack of sufficient ground data for classifier training hampered the complete success of the project.

Key Words: LANDSAT, NASA, cloud cover, regression estimate, direct expansion.

MARKOVIAN TIME-DELAY SAMPLING POLICIES. Y.V. Hui and D.R. Jensen, Department of Statistics, VPI&SU.

Let the possible values of the quality characteristics of a production process be partitioned into k disjoint regions $\{I_1, I_2, \dots, I_k, R\}$ reflecting departures of the process from control, R being the out-of-control state where remedial action is prescribed. A time-delay model for monitoring the process is developed in which the occurrence of a sample outcome in the region I_k is followed by a delay of d_k time units before another sample is taken, the sampling frequency increasing as the process drifts further from control. The occurrence of an outcome in R is followed by the lapse of A time units for adjusting the process before sampling resumes.

The sampling scheme is formulated as an aperiodic recurrent Markov process. The variance and expected number of samples taken, and the variance and expected number of adjustments to the process, are studied for a monitoring period of length T . Some related models and an extension to multiple rejection regions are presented. A cost model is developed for choosing a particular time-delay sampling policy and for budgeting future sampling efforts under such a policy.

SOME NEW RESULTS IN THE STATISTICAL INFERENCE OF STABLE LAWS.
I.A. Koutrouvelis*. Dept. of Mathematical Sciences, Va.
Commonwealth Univ., Richmond, Va. 23284

The need to study stable distributions has recently increased, due mainly to the increasing number of applications these distributions find in many fields. However, inferences associated with stable laws are especially intricate, as closed forms for the density functions are non-existent with only a few exceptions. This paper examines a regression method of estimation of the parameters which utilizes the empirical characteristic function. The asymptotic properties of the estimators are investigated in the special case of symmetric stable distributions.

THE ANALYSIS OF VARIABLE SELECTION IN LINEAR REGRESSION ACCORDING TO THE STANDARDIZED TOTAL MEAN SQUARED ERROR.
Yuk-Miu Lan and Raymond H. Myers. Dept. of Statistics, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

One of the criteria called the C_p statistic for selecting appropriate regressor variables in linear regression was proposed by Mallows (1964). It is an estimate of the standardized total mean squared error Γ_p defined by

$$\Gamma_p = \frac{1}{n} \sum_{i=1}^n E[\hat{y}_{pi} - E(y_i)]^2$$

where \hat{y}_{pi} is the least squares prediction at the i th data point when fitting a linear regression equation with p variables. It is suggested that subsets with smaller C_p and C_p close to p be considered.

In this paper we would construct an approximated confidence interval for the Γ_p and consider various situations in comparing different regression models in terms of the corresponding Γ_p 's. For the simplest case, we would compare a p -term model with its subset model, an s -term model by testing $H_0: \Gamma_s \leq \Gamma_p$ vs. $H_1: \Gamma_s > \Gamma_p$. The test would involve a non-central F -distribution with noncentrality parameter $\lambda = \frac{p-s}{2}$.

The analysis can be extended to comparing r consecutive models in which variables chosen have a definite order.

MEASURING AGREEMENT FOR CATEGORICAL DATA: WE GANG AFT AGLEY.
J.E. Mann*, R.S. Schulman*. Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061.

The measurement of agreement for categorical data is often based on a $k \times k$ table of observed proportions. Such tables generally arise from the cross-classification of n observations by 2 judges, or the cross-classification of category selections by n pairs of observers. In either case the observed proportion of agreement should be corrected by removing the proportion of agreements to be expected by chance.

Two measures of agreement, involving different corrections for chance agreement, are discussed. κ_A involves a correction term based on totally random cell assignments, while \kappaappa employs a correction based on the marginal proportions. Based on logical considerations and examination of examples, it is argued that \kappaappa should only be employed when the experiment involves 2 judges whose category assignments are constrained by pre-determined marginal distributions. The main thrust of this argument is that agreement on the marginal proportions is part of the notion of agreement, and that \kappaappa only assesses agreement relative to the similarity of the two margins.

A BAYESIAN APPROACH TO THE ESTIMATION OF THE SIZE OF WILDLIFE POPULATIONS. Philip J. Smith, Dept. of Biostatistics, Med. Col. of Va., VCU, Richmond, Va. 23298

In the Bayesian context little practical work has been done with regard to optimization and estimation in multiple capture recapture surveys. The purpose of the talk is to present useful Bayesian results regarding these aspects. It is shown that for most specifications of the loss function, the Bayesian optimal estimate for the size of the population resembles the classical Schnabel estimate, thereby attesting to its efficacy. Also, a framework is given from which the optimal stage at which to terminate sampling may be obtained.

MARKOV CHAINS AND SEQUENTIAL PROBABILITY RATIO TESTS.
W.H. Woodall and M.R. Reynolds. Dept. of Statistics, Va. Polytechnic Institute, Blacksburg, Va. 24061

Properties of certain sequential probability ratio tests (SPRT's) can be determined closely by the construction of approximate tests for which exact properties can be calculated using the theory of Markov chains. This approach is especially useful when the cumulative sum test statistic of an SPRT is a discrete random variable.

For the approximate Markov chain representation of an SPRT, exact expressions are presented for the OC function, the p.m.f. of the decisive sample number (DSN), the factorial moments of the DSN, and the conditional distribution of the DSN given that the null hypothesis is either accepted or rejected. The p.m.f. of the DSN is viewed as a generalization of the univariate geometric distribution and its limiting form for large values can be used to examine the effects of truncation. A method of constructing bounds on the OC function of an SPRT is given. These results can be used to closely determine the optimal stopping bounds of an SPRT. Convergence properties of the Markov chain representation of an SPRT are summarized.

~~505-73~~
~~V81a1~~
V5X/114

VIRGINIA JOURNAL OF SCIENCE

VOL. 32, NO. 1
SPRING 1981

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware
Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer
Box 637
Lancaster, Va. 22503

©Copyright, 1980 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P.O. 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia and additional entry at Harrisonburg, Virginia 22801. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1980: \$15.00 per year, U.S.A.; \$20.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$4.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send *address changes* to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper (8½ × 11 inches). Margins should be not less than 1¼ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and affiliation, and proposed running title, all appear-

ing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first and last page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

- Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.
- Spry, A. 1969. *Metamorphic Textures*. Pergamon Press, New York. 350 pp.
- Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians, Part III. Vertebrates* (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 32

No. 1

Spring 1981

TABLE OF CONTENTS



ARTICLES

- | | |
|---|----|
| On the Teaching of Origins. <i>Michael L. Bentley, Roanoke Valley Science Museum</i> | 2 |
| Aflatoxin Occurrence in 1977 Corn in Virginia. <i>Gerald C. Llewellyn and Judith S. Katzen, Virginia Commonwealth University</i> | 4 |
| Phrymaceae and Plantaginaceae in Virginia. <i>Miles F. Johnson, Virginia Commonwealth University</i> | 12 |
| Distribution and Compensation of the Macrophyte Community of Mountain Lake, Virginia. <i>Charles E. Dubay and George M. Simmons, Jr., VPI & SU</i> | 17 |
| Vascular Flora and Vegetation of the Kent Branch Watershed, Fluvanna Co., Virginia. <i>George M. Diggs, Jr. and G. W. Hall, College of William and Mary</i> | 23 |

On the Teaching of Origins

Michael L. Bentley

Assistant Director
Roanoke Valley Science Museum
2323 Overlook Dr. N.E.
Roanoke, VA 24012

Abstract—Science is empirical and seeks naturalistic explanations for phenomena. Theories must be open to modification based on evidence. The theory of evolution, though it is incomplete, meets these criteria. The movement to require the teaching of creationism in the public schools as an equally valid scientific model is opposed on the grounds that creationism does not meet these criteria of science. Science teachers are advised to teach children the limits of science and the tentativeness of knowledge.

The human understanding when it has once adopted an opinion draws all things else to support and agree with it.

—Francis Bacon

Knowledge comes to man in many ways. One of the most powerful and successful ways of knowing is science. This is so because science begins with observation and later returns to observation in its method of verification. On the basis of empirical evidence, theories, the products of science, are proposed, and it is through theories that human understanding of nature is advanced. It is assumed, however, that theories only stand for as long as they best explain the evidence. They must be modified when new evidence not explained by them is discovered, or abandoned when better explanations are proposed.

Over a hundred years ago the English naturalist, Charles Darwin, pondered the apparent waste of life in nature. Thousands of frog eggs, for example, yielded only replacement numbers of frogs. This and many other observations eventually led Darwin to propose the theory of the origin of species by natural selection.¹ The key idea of the theory is that such natural selection is the mechanism for changes in the kinds of living things. Given a great number of offspring possessing various traits, those that survive to reproduce are more likely to have traits favoring survival. Over long periods of time and many generations, this differential survivorship yields organisms that are more adapted to the conditions of their surroundings. Organisms that survive will eventually become tuned to their particular environments. As there are many different environments, adaptive changes result in more kinds of organisms; initially simple structures and patterns of behavior become more complex.

Darwin's idea has been so successful that its up-to-date version, the modern synthetic theory of evolution, is now widely recognized as the organizing principle of the life sciences. It is, "perhaps the most important contribution yet made by biologists to our understand-

ing of what the world is like and how it came to be like that."² Despite this, the theory of evolution is not complete. Darwin did not understand how variation within species originated. He did not know of genes. Since his time many improvements have been made to the theory with contributions by geneticists, geologists, archaeologists, ethologists, and biochemists, among others. But mysteries still remain to be solved. For example, the explanation of the evolution of life from non-living molecules is far from satisfactory. An organic brew indeed can be concocted in the laboratory by sparking early-earth type gases, but this soup of amino acids would still require an incredible leap to become replicating macromolecules and proteins.

Another gap is in the fossil record. While fossils strongly support the general pattern of evolution, the absence of clear transitional forms is still puzzling. There are also many unresolved problems in dating the ages of rock strata. Different radiometric techniques result in inconsistent ages. Also yet to be accounted for is the amazing perfection of structures such as the human brain. The problem of perfection led to a split between Darwin and Alfred Russell Wallace, co-founder of the theory. Wallace could not bring himself to apply the theory to the human mind, which he viewed as the only divine contribution to the history of life.³

Scientists from many disciplines are doing research that could shed light on these unresolved problems, but the basic framework of the theory is firmly intact. There are a small but growing number of scientifically trained individuals, however, that question the very foundation of the theory. Such criticism is not new. The great geneticist, J. B. S. Haldane, wrote twenty years ago:

The history of science makes it almost certain that facts will be discovered which show that the theory of natural selection is not fully adequate to account for evolution. But the same history makes it extremely improbable that these facts will be in any way related to the criticisms at present made of it. The physics of Newton and Galileo have proved inadequate in several respects, and are being replaced by relativistic and quantum mechanics. These, however, are even further from the medieval physical theories than were the theories of Galileo and Newton.⁴

The current critics are also advancing a very ancient replacement for the theory of evolution, that of Special Creation. The campaign for creationism is being led by three groups: The Creation Research Society of Ann Arbor, Michigan, the Creation Science Research Center and the Institute for Creation Research, both of San Diego. They have created a stir out of proportion to their numbers, not so much in scientific circles but in public education. The stated goal of these groups is that the creation model for the origin of species should be taught in the public schools along with evolution, as equally valid *scientifically*.⁵ Their views have attracted much financial support from fundamentalist Christian groups and individuals and they have been able to publish a wide array of literature, produce professional quality films and other media, and engage in nationwide public speaking tours.

The creationist societies have had successes. Among the states which have adopted an "equal time" policy for science textbooks are Mississippi and Indiana. In other states such as Georgia, Texas, Illinois, and Virginia some local school authorities are requiring the presentation of both evolution and creationism in science classes.

From a realization that the evolution-creation controversy can not be ignored by science educators, I attended a creationist-sponsored conference recently in Raleigh, North Carolina. The reactions and questions from the audience of over three hundred people indicated strong support for the creationist thesis. These supporters included many well-educated people, including science educators at the elementary school, secondary, and college levels. The presenters were Dr. Henry M. Morris and Dr. Gary E. Parker. Dr. Morris' background is in geology, hydraulics, and engineering. He was formerly department head in civil engineering at Virginia Polytechnic Institute and State University. Dr. Parker's training is in biology and science education. No doubt as a result of many such presentations, the alternating speeches of Morris and Parker were polished, pointed, and very convincing. Most of their arguments detailed the shortcomings of the theory of evolution. I had heard most of these before, but never as part of an attack on the basic ideas of evolutionary theory. Some time was also spent describing the creation model, which agrees literally with the Biblical account of creation. This model is "scientific" because it accepts that science has learned more about nature since Biblical times. Hence DNA, mutations, and the fossil record must be accounted for, and the creation model does so, the adherents contend, better than the theory of evolution.⁶

It is not the intent here to respond to the arguments for or against either model. I instead want to address the goal of this movement, i.e. to include creationism with evolutionary theory in the school curriculum as a scientifically valid explanation of natural phenomena. I believe this must be resisted by science educators. At first sight it might appear fair and unobjectionable to present children with the evidence for both ideas about origins, but the creationist model simply does not have

the same kind of scientific validity as the theory of evolution. That is not to say that it can not be a true account of the origin of life; it could. However there are three reasons why creationism isn't *scientific*. First, the theory was not constructed from observations. The creationists started with the full-blown theory, the Genesis account, and then fit evidence into the theory. This is the opposite of the way science proceeds. Second, since most creationists interpret scripture literally and hold it as the immutable word of God, they would likely be unwilling to modify their theory regardless of new evidence. This, again, is the antithesis of science. Science values open-mindedness, even though scientists themselves are human and can be just as blind and stubborn as anybody. Third, the creationist model violates "Occam's razor." "*Pluralitas non est ponenda sine necessitate*," or "make no more hypotheses than necessary," said William of Occam. This basic principle of science is transgressed when causes outside of nature, supernatural causes, are invoked for explanations. This is not to say that a supernatural being could not have created the universe, but that it cannot be defended as a *scientific* account. The origin of life took place long ago and no theory as to how it happened can ever be tested in a laboratory sense. Nevertheless the theory of evolution is in every sense a scientific theory: it has been built from observations; it has already been modified many times to account for the evidence and it is open to further modification; and it seeks naturalistic explanations for observed phenomena. For these reasons the evolutionary explanation, despite its incompleteness, is a scientific explanation. Creationism, failing on all three, is not.

The creationists do make a very important point. The theory of evolution should not be taught in school as fact. Children should learn in science classes the assumptions upon which the theory is based. They should be made aware of its shortcomings. They should, in fact, learn to appreciate the tentativeness of *all* scientific knowledge. Science *does* have limitations. There is no question but that teachers of science have been remiss on this account, perhaps a reflection of their own misunderstanding of science. It is only when one understands the limits of science that its power becomes clear.

Footnotes

¹Charles Darwin. *The Origin of Species*, 6th ed. (Harmondsworth: Penguin Books, 1968).

²John Maynard Smith. *The Theory of Evolution*, 3rd ed. (Midlexex, England: Penguin Books, 1975), p. 9.

³Stephen Jay Gould. *Ever Since Darwin* (New York: W. W. Norton & Company, 1977), p. 25.

⁴J. B. S. Haldane. "Natural Selection," in *Darwin's Biological Work*, ed. by P. R. Bell (New York: John Wiley & Sons, 1959), p. 148.

⁵Morris, Henry M. *The Remarkable Birth of Planet Earth* (San Diego: Creation Life Publishers, 1972).

⁶R. B. Bliss. *Origins: Two Models: Evolution, Creation* (San Diego: Creation Life Publishers, 1976).

Aflatoxin Occurrence in 1977 Corn in Virginia

Gerald C. Llewellyn and Judith S. Katzen

Department of Biology
Virginia Commonwealth University
Richmond, Virginia 23284

Abstract—A review of aflatoxin contamination of corn and how it relates to Virginia and the Southeastern corn belt is presented. Data for aflatoxin levels in Virginia corn samples are reported and analyzed beginning with the 1977-1978 crop year. Extensive analysis of Virginia corn for aflatoxin was initiated following a survey conducted to determine the extent of aflatoxin contamination in corn produced in Virginia. A free testing service for Virginia producers and users was provided. Approximately 1000 samples were collected according to certain specifications and then shipped to the Division of Consolidated Laboratory Services in Richmond for analysis. Screening for aflatoxin was accomplished by the mini-tube method. Results were divided as to samples containing 0 to 20 ppb aflatoxin, 21 to 100 ppb, 101 to 400 ppb, and greater than 400 ppb total aflatoxin. An attempt was made to correlate these results and the location in the state in which the corn was grown. It seemed, according to this data, that the Tidewater and Northern Virginia regions had the greatest problems. These problems correlated with a drought-wet sequence in climatic conditions. Air temperature did not appear to contribute to the problem. These climatic conditions, possibly in conjunction with insect damage, appear to be unique for the crop year of 1977-1978.

Introduction

Aflatoxin is a problem as a contaminant of many agricultural products. *Aspergillus flavus*, the toxigenic mold that produces aflatoxin, grows on many plant products. Corn tends to be one of the primary targets for both the fungus and its toxin (Golumbic and Kulik, 1969). A correlation to the problem can be made between aflatoxin occurrence and geographical regions. The problem becomes even more important when the widespread uses of corn are recognized.

Large populations of animals and humans consume diets including corn. Tortillas are made in most Latin American countries and are even becoming the fad in fast food restaurants in the United States. Corn is important to swine production (Jensen *et al.*, 1977) and to other animal feeds. Corn is also used for milling and brewing as well as for export. Hence, if large quantities of aflatoxin are found, there is a possible bioconcentration problem for humans.

Prior to 1970, little was known about aflatoxin. However, its frequency was sufficient to cause some concern. As early as 1963, Spensley (1963) felt there was no real danger as long as proper steps were taken to ensure little or no mold proliferation. It was found that optimum conditions for fungal growth was a temperature of 30°C and a humidity level of 80-85%. Also a moisture content of the substrate in the range of 15-28% was needed.

The earliest tests evaluating aflatoxin in corn were made in 1964, 1965, and 1967 on all grades of corn in the Midwest or Cornbelt. There was very little incidence of aflatoxin (2.1-2.3%), with a range of 3-37 ppb from all the contaminated samples, and these only from the lower grades of corn (Shotwell *et al.*, 1969; Shotwell *et al.*, 1970).

Then in 1968-1969, a survey was conducted on export corn from ten ports on all grades except U.S. #1. Again the poorer grades contained the toxin and only in small quantities; 2.7% was contaminated and contained 6-25 ppb (Shotwell *et al.*, 1971).

However, it should be noted that in those early years there was a cause for concern in the southern United States that has continued through the present time. This illustrates the fact that the aflatoxin problem is somewhat regional. In 1969 and 1970, crop samples taken in North Carolina, South Carolina, and Virginia were all aflatoxin-negative. The following year, 14 out of 22 samples were aflatoxin-positive and 12 samples contained greater than 20 ppb. It also can be noted from these studies that the samples with the highest toxin levels were from the lowest grade of yellow corn and were in corn with a moisture range of 19.1-20.6% (Shotwell *et al.*, 1973).

More studies were made on corn by regions. Rambo *et al.* (1974) tested preharvest yellow and white dent corn during 1971 and 1972 from Indiana and Kentucky. Those samples taken in 1972 in Indiana were tabulated by regions also; northern counties, central counties, southern counties, and Evansville, Indiana. A total of 0.11% of the kernels were infected and these were found only in the southern counties and Evansville. Although there was an increase over the previous year's incidence, the increase only amounted to 1.0%.

Shotwell *et al.* (1971, 1978) also made studies in the Midwest. They found in Missouri in 1971 that 13% of the aflatoxin-contaminated corn exceeded 20 ppb. The most recent studies involved Illinois, Indiana, Iowa, Kansas, Nebraska, Ohio, and Wisconsin. Of the 923 samples taken, only three contained aflatoxin at levels over 20 ng/g. Those violating the Food and Drug Administration's guidelines (> 20 ppb) comprised only 0.3%, and only 0.6% contained detectable levels.

While aflatoxin levels in corn from the Midwest appear to stay relatively low (usually 2-3% with only a trace amount of samples containing greater than 20 ppb), such is not the case in the South. From samples taken during 1969, 1970, 1971, and 1973 throughout

the South, levels exceeding 20 ppb ranged from 13-32% (Shotwell, 1977). For other samples taken in Virginia during 1976, 27% exceeded 20 ng/g. The state of Georgia seems to have the most severe problem. In the 1977-1978 crop season, 75% contained greater than 20 ppb and 25% surpassed 400 ppb (Brown, 1978).

In light of all these studies, definite conditions for the growth of *A. flavus* and aflatoxin production have been documented. Primary occurrence of the toxin begins in preharvest corn, although a storage problem is possible (Goldblatt *et al.*, 1977). As noted earlier, fungal growth and resultant aflatoxin synthesis needs high moisture levels. Also related are a heavy insect population and resultant damage, or drought, then a wet harvest period with concurrent insect damage (Brown, 1978). In addition, causative agents include wind spreading of *A. flavus* spores, rough handling of corn during harvest, and geographical location, which cannot be divorced from the problems caused by high moisture content and weather conditions.

Storage conditions can also cause problems when the outside bins in which the corn is stored gathers moisture around the windows, probably contributing to the occurrence of a "hot spot". In these areas, moisture levels and mold levels become sufficiently high to cause substantial aflatoxin in the center of the "hot spot" (Hesseltine, 1974).

However, with the development of rapid testing procedures and detoxifying methods, some concern about aflatoxin could be reduced. There are three basic analyses for aflatoxin. The first is a rapid presumptive test by visual inspection under longwave ultra-violet light. A positive test shows a BGYP, bright greenish-yellow fluorescence (Shannon *et al.*, 1978). This method is not very reliable as aflatoxin may form beneath the testa and the BGYP may not show up. Therefore, when this testing is attempted, the kernel and other parts of the plant should be coarsely ground. Also, once a positive test shows, a quantitative method is in order. The second parameters are rapid screening procedures to confirm the toxin's presence (qualification), but not levels (quantitation), and usually use the glass mini-column and thin layer chromatography (TLC). A final parameter is a chemical test for actual quantitative measurements.

Methods of detoxifying that have been tried include ammoniation of corn. This significantly reduces the aflatoxin. When feed that has undergone ammoniation is supplemented with non-ammoniated, non-contaminated corn, swine show no difference as to preference over non-supplemented, non-contaminated corn (Jensen *et al.*, 1977). Other methods include alkaline treatment with calcium hydroxide, as is used in the making of tortillas (Ulloa-Sosa *et al.*, 1968).

For the entire aflatoxin problem, prevention of the mold growth would be the best approach. Insecticides reduce but do not eliminate toxin occurrence (Lillehoj *et al.*, 1976). Also, possibilities include a choice of hybrid crops that tend to be resistant in certain geographic areas which can be coupled with a program for insect control. Finally, avoidance of excessive water

accumulation in stored corn may not prohibit aflatoxin altogether, but it may provide the farmer with sufficient usable feed for livestock or a profitable business in corn (Lillehoj *et al.*, 1976, 1978).

It became evident in the fall of 1977 that a high incidence of aflatoxin contamination of corn was occurring in the Southeast. The state of Virginia became aware of this and began the analysis of newly harvested corn. Virginia ranks 20 out of 41 states producing corn. This represents 0.75% of the corn production in the U.S. for grain. In the state of Virginia, corn produced for grain ranks second to tobacco in money value (Schooley *et al.*, 1976). Geographically, Virginia is considered one of the northern most states in the southern corn producing area. Also, there is adequate evidence that toxigenic mold is present in the agricultural areas of the state. Evidence to support this includes the continued low level contamination of peanuts produced in the state (Sledd *et al.*, 1976). Some areas of the state produce both corn and peanuts.

The data presented and analysed herein will be based upon a six month study of approximately 1,000 samples of corn from the state of Virginia that were analysed for aflatoxins. An effort was made to correlate rainfall, geographic regions, and the number of samples contaminated with various levels of aflatoxin. This study was undertaken in the fall of 1977 when the Southeast appeared to have its most extensive occurrence of aflatoxin-contaminated corn known in recent history.

Materials and Methods

History and Preliminary Tests

The Mycotoxin Laboratory of the Virginia Division of Consolidated Laboratory Services began a program of testing for aflatoxin in corn at the request of the Marketing Division of the Virginia Department of Agriculture on September 1, 1978. The purpose of the survey was to determine the extent of aflatoxin contamination in corn being marketed in Virginia. The samples were collected from grain dealers and buying stations to determine generally the situation in Virginia. It was soon recognized from the survey results that there was a need to provide a testing service for Virginia producers and users in order that they may be better informed. On September 30, 1978, the Commissioner of Agriculture and Consumer Services requested of the Director of Agriculture and Natural Resources at Virginia Polytechnic Institute and State University (VPI & SU) that a service testing program be implemented through the extension service. Early in October, the Cooperative Extension Service of VPI & SU announced to all corn growers and others buying or feeding corn the procedure for free testing as outlined by the Virginia Department of Agriculture and Consumer Services. Instructions were given for sampling, shipment, sample identification and reporting of results. As a result the state soon began testing corn samples sent not only by the Marketing Division but

by the extension agents, Agriculture and Soil Conservation inspectors, Virginia food and feed inspectors, and individual farmers, millers, farm bureaus, veterinarians, and the Virginia Department of Animal Health and Dairies.

Procedures for testing were carried out in several steps. The first step involved sampling the corn, with as much representation as possible assured by the corn being taken from many areas within the lot. Also the sample size had to be a minimum of two pounds and a maximum of three pounds. Next came shipping in plastic bags that had been adequately packaged for mailing to: Division of Consolidated Laboratory Services, 1 North 14th Street, Room 350, Richmond, Virginia 23219. Sample identification followed such that, a) all samples were identified as corn for aflatoxin analysis, b) lot number, bin number, *etc.* were used so that the report could be related to an identified lot of corn, c) all names and complete mailing addresses of all persons who were to receive a copy of the laboratory report had to be included, along with d) the name of the county in which the corn was produced.

Laboratory findings were reported in the following ranges: 1) none detected, 2) less than 20 parts per billion (ppb), 3) 21 to 100 ppb, 4), 101 to 400 ppb, 5) greater than 400 ppb. These reports were sent to the extension agents and others requesting this information. Finally, these results were interpreted as follows: a) corn containing less than 20 ppb aflatoxin can be used for human consumption and can be fed to all animals regardless of size or maturity, b) corn with more than 20 ppb should not be used for human food or fed to dairy animals or sows suckling their young, c) corn having 21 to 100 ppb aflatoxin can be fed to mature beef animals, poultry and swine (Mature animals are considered to be those beyond the age where a starter ration is normally fed.), and d) corn found in excess of 100 ppb should not be fed to animals of any size or stage of maturity since evidence exists that feeding corn such as this can cause decreased feed efficiency, depressed growth rate, lesions on the liver and kidneys, and possible residues of aflatoxin in meat, milk, or eggs.

Quantitation of Aflatoxin Levels

The testing of corn for aflatoxin was done at the Virginia Division of Consolidated Laboratories by the mini-tube method (Romer, 1975). This method has been adopted as an official first action method the Association of Official Analytical Chemists and appears in the official manual as Minicolumn Detection Method 26.A01-26.A08. Positive samples of less than 20 ppb are not given a quantitative measurement by TLC. Likewise, samples of 21 to 100 ppb, 101 to 400 ppb, or greater than 400 ppb are not measured by TLC unless they are official state samples requiring regulatory action. In the latter case two determinations of a second portion of the sample are run before reporting the test results.

Only corn samples known to be grown in Virginia were reported in this study. Also the preliminary study by the Marketing Division was not included since it lacked specific data such as origin of the corn.

Results

Climatological Data

Virginia was divided into six regions with titles that describe the geography of their respective land. Moving from the western part of the state to the western and finally southeastern part are Tidewater, Eastern Piedmont, Western Piedmont, Northern, Central Mountains, and Southwest Mountains (Fig. 1). Since drought may be a factor in aflatoxin generation, two of these areas, Tidewater and Northern were studied in 1977 as to their precipitation deviations from means in inches and temperature in degrees Fahrenheit (Smith, 1977) during the months that correspond to the season of growth-to-harvest of corn (Table 1). Total precipitation for this period deviated from the mean by -0.18 in Tidewater and -0.19 in Northern region, while the temperature was above average for both areas.

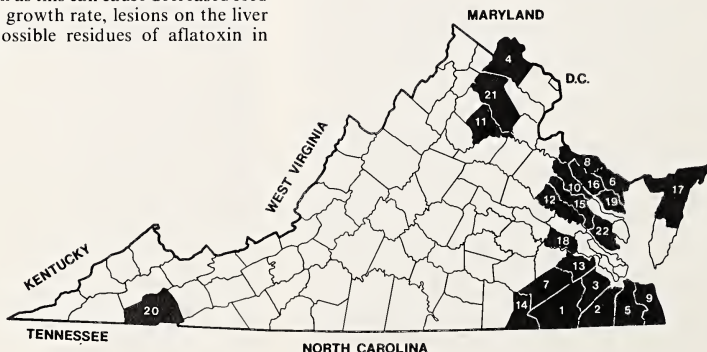


FIG. 1—Geographic location of the top 22 corn producing counties in 1976 in Virginia. Eighteen counties were in the Tidewater Region, three in the Northern Region, and one in the Southwestern Mountain Region.

Table 1. Precipitation with accumulations and air temperature deviations from the normal for two regions in Virginia (1977).

Parameters	<u>Tidewater Region</u>								<u>Mean Deviations</u>
	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>	
Precipitation (inches)	-0.47 (accum.)	0.47 (0.00)	-1.55 (-1.55)	-1.75 (-3.30)	-1.48 (-4.78)	-1.23 (-6.01)	2.95 (-3.06)	1.62 (-1.44)	-0.18
Temperature (°F)	3.0	0.6	-1.7	2.3	2.7	2.8	-2.8	2.1	1.13
Parameters	<u>Northern Region</u>								<u>Mean Deviations</u>
	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>	
Precipitation (inches)	-0.38 (accum.)	-2.20 (-2.58)	-1.46 (4.04)	-0.62 (-4.66)	-0.84 (-5.50)	-0.86 (-6.36)	1.27 (-5.09)	3.56 (-1.53)	-0.19
Temperature	2.3	2.1	2.3	2.0	1.3	1.9	-3.7	1.2	1.16

Table 2. Production of corn in most Virginia counties during 1975 and 1976 crop years^a.

<u>Rank</u>	<u>1975</u>	<u>Bushels (10⁶)</u>	<u>1976</u>	<u>Bushels (10⁶)</u>
	<u>County</u>		<u>County</u>	
1	Southampton	2.85	Southampton	4.16
2	Isle of Wight	2.23	Suffolk City	2.75
3	Suffolk City	1.85	Isle of Wight	2.49
4	Loudoun	1.50	Loudoun	1.93
5	Westmoreland	1.46	Chesapeake City	1.49
6	Sussex	1.43	Northumberland	1.32
7	Surry	1.39	Sussex	1.28
8	Northumberland	1.31	Westmoreland	1.27
9	Culpeper	1.26	Va. Beach City	1.26
10	King William	1.09	Essex	1.15
11	Chesapeake City	1.09	Culpeper	1.10
12	Essex	1.06	King William	1.09
13	Va. Beach City	1.06	Surry	1.02
14	Richmond	1.04	Greensville	0.97
15	Fauquier	0.93	King and Queen	0.96
16	Accomack	0.93	Richmond	0.89
17	King and Queen	0.93	Accomack	0.84
18	Pittsylvania	0.90	Charles City	0.81
19	Rockingham	0.89	Lancaster	0.79
20	Augusta	0.89	Washington	0.78
21	Halifax	0.84	Fauquier	0.76
22	Madison	0.79	Gloucester	0.68
23	Hanover	0.78	Pittsylvania	0.65
24	Caroline	0.76	Madison	0.64
25	Lancaster	0.73	Halifax	0.63
26	Mecklenburg	0.73	Rockingham	0.61
27	Orange	0.72	Middlesex	0.61
28	Gloucester	0.69	Augusta	0.59
29	Greensville	0.68	Orange	0.56
30	Prince George	0.68	Prince George	0.53
31	Charles City	0.67	Hanover	0.53
32	Dinwiddie	0.60	Caroline	0.48

^a From: Virginia Agricultural Statistics, Bulletin No. 42, Sept. 1977, Va. Cooperative Crop Reporting Service, Richmond, VA

Table 3. Distribution groups showing the number of corn samples submitted on a county basis (Sept. 1, 1977-March 2, 1978)^a.

Number of Samples Submitted	Number of Counties Submitting Samples	Percent of all Counties Submitting Samples
1-5	31	39%
6-10	14	18%
11-15	12	15%
Subtotal	57	73%
16-20	5	6%
21-25	6	8%
26-30	4	5%
31-35	3	4%
36-40	1	1%
41-45	0	-
46-50	0	-
51-55	1	1%
56-60	1	1%
61-65	0	-
66-70	1	1%
Subtotal	22 ^c	27%
Total ^b	79	100%

^a A total of 70 counties or cities submitted samples for analysis.

^b A total of 997 samples were tested.

^c 665 of the 997 samples were from these 22 counties.

Harvest and Infestation Data

In 1976, Virginia corn for grain shows 615,000 acres harvested with a production value of \$119,187,000. According to the Virginia Cooperative Reporting Service (Schooley *et al.*, 1977), corn for grain was the second ranking crop in the state, competing with hay and tobacco. In comparison to corn for grain produced by other states, Virginia ranks 20th out of 41 corn producing states, and Virginia constitutes 0.75% of the total U.S. production. Virginia sweet corn production is substantially smaller than corn for grain. In 1976, it was grown on 1,400 acres, ranked 15 in the state, and had a production value of \$1,688,000. Nationally sweet corn production rank was 16th in 17 producer-states and amounted to 0.96% of the total produced in the U.S.

From Table 2 and Figure 1, the rankings and quantity for corn production of all the counties in Virginia and the top 22 counties, respectively, can be seen. It can also be noted that the top ranking counties are found primarily in Tidewater and Northern regions. Table 3 gives the distribution groups on a county basis showing the number of corn samples submitted for aflatoxin testing as reported in this study.

Starting with Table 4 and Figure 2, the rankings of the counties within the state and their corresponding levels of contamination in parts per billion are also revealed. Table 5 represents the rank of counties with primarily 101-400 ppb but also includes other levels. Again it should be noted that these are located primarily in Tidewater.

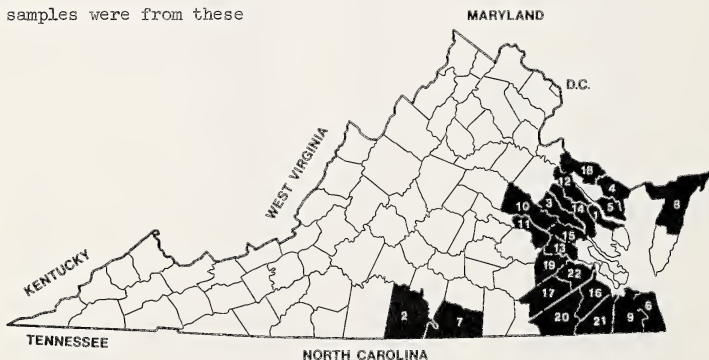


FIG. 2—Rankings by number for the top 22 counties submitting samples that exceed 20 ppb aflatoxin. Only counties submitting 16 or more samples are included. They involve three Eastern Piedmont counties (7, 10, & 11), one Western Piedmont county, the rest are in the Tidewater Region.

Table 4. Ranking of all Virginia counties submitting samples and having ≥ 20 ppb aflatoxin (Sept. 1, 1977-March 2, 1978)^a.

City or County	% Submitted Samples Contaminated ^b	Number of Samples Tested
Buckingham	100%	2
Brunswick	67%	6
Charlotte	67%	6
Middlesex	56%	18
Lunenburg	50%	14
Gloucester	42%	14
Halifax	42%	24
Northumberland	36%	28
King William	35%	17
Stafford	33%	3
Lancaster	32%	25
Virginia Beach (City)	31%	26
Richmond (County)	31%	13
Northampton	29%	14
Matthews	29%	7
Mecklenburg	29%	34
Pittsylvania	27%	11
Accomack	25%	20
Amelia	25%	4
Caroline	25%	4
Chesapeake (City)	25%	20
Franklin (County)	25%	4
James City	25%	8
Nottoway	25%	4
Hanover	24%	54
Henrico	23%	22
Dinwiddie	21%	14
Essex	21%	28
Greensville	21%	14
Washington	20%	10
Cumberland (City)	20%	5
Charles City	19%	69
King and Queen	18%	22
Page	17%	6
New Kent	15%	39
Richmond (City)	14%	14
Petersburg (City)	13%	8
Sussex	13%	24
Isle of Wight	13%	60
Westmoreland	12%	25
Prince George	10%	29
Carroll	8%	13

^aTotal of 42 counties or cities submitted samples.

^bMean percent with standard deviation: 28.9 \pm 17.6.

Table 5. Virginia counties having samples of corn containing various levels of aflatoxin (Sept. 1, 1977-March 2, 1977).

County	101-400 ppb	(%)	(Rank)	≥ 400 ppb	21-100 ppb	≥ 20 ppb
Charles City	2/69 ^a	2.9	14	-	11/69	26/69
Chesapeake (City)	1/20	5.0	9	-	4/20	7/20
Essex	2/28	7.1	7	-	4/28	11/28
Halifax	2/24	8.3	5	-	8/24	2/24
Hanover	2/54	3.7	11	-	11/54	23/54
Isle of Wight	2/60	3.3	13	-	6/60	2/60
King William	2/17	11.8	4	1/17	3/17	4/17
Lancaster	1/25	4.0	10	-	7/25	9/25
Middlesex	4/18	22.2	1	-	6/18	5/18
Northampton	1/14	7.1	8	-	3/14	3/14
Northumberland	6/28	21.4	2	-	4/28	7/28
Prince George	1/29	3.4	12	-	2/29	8/29
Richmond (County)	1/13	7.7	6	1/13	2/13	5/13
Washington	2/10	20.0	3	-	-	-
New Kent	0/39	-	-	1/39	5/39	10/39
Total (15)	29/339 ^b					

^aSamples/total samples tested from that county is given.

^bWhen compared to the total samples tested in Virginia (29/997)=2.9% had 101-400 ppb.

A summary of the number of counties submitting samples, levels of contamination, and percentages is found in Table 6. More than 15.5% of the samples tested fell specifically within the Virginia limited-use guidelines, while approximately 81% of the corn tested fell with FDA guidelines (contain less than 20 ppb). Only 3.2% is not usable by FDA or Virginia guidelines.

Table 6. Summary of counties submitting samples, levels of contamination, and corresponding percentages.

Counties Submitting Samples	Total Samples Tested	None Detected	≥ 20 ppb	21-100 ppb	100-400 ppb	≥ 400 ppb
79	997	572	236	157	29	3
Counties Growing Corn	% of Counties Submitting Samples	% ND	% ≥ 20 ppb	% 21-100 ppb	% 100-400 ppb	% ≥ 400 ppb
97	81.4	57.4 ^b	23.4 ^b	15.7 ^c	2.9 ^d	0.3 ^d

^aHad a minimum of 200 acres of corn in 1975 and 1976.

^b81.1% of the corn tested fell within FDA guidelines.

^c15.7% of the corn tested fell within VA limited use guidelines (total of 96.8% usable).

^d3.2% of VA corn tested was not usable.

Discussion

It is evident that Virginia did have an aflatoxin problem as illustrated by approximately 1000 samples tested. This problem follows the pattern thus far seen in several areas in the United States in that it was regional, becoming acute in specific counties, and it seemed to relate positively to a sequence of drought followed by increased wetness.

Drought is defined by Palmer (Smith, 1977) as a "prolonged and abnormal moisture deficiency". Indicative of normal moisture or wet conditions are the index values on the positive side, while negative values

correspond to the drought severity. Negative precipitation values for both monthly and accumulative data are reported in Table 1. It can be noted that there was a drought in these counties in Virginia during this time. When considering some counties with a notable aflatoxin problem in corn in Tidewater and Northern regions, both of which had a concurrent problem, the above mentioned sequence of drought followed by a wet period was seen. Notwithstanding, it does appear that temperature as mentioned by deviations from the mean is not as important as precipitation. Eighteen of the 22 top corn producing counties are located in Tidewater and three are located in the Northern region. Therefore, most of the corn produced in Virginia was exposed to drought.

The Tidewater region is implicated as a major area for aflatoxin contaminated corn when 20 of the top 22 counties submitting 16 or more samples had greater than 20 ppb aflatoxin and fall within this region. The top five counties are also located in Tidewater. When considering samples of greater than 20 ppb, the trend continues. For example, Richmond County, which did not achieve the 15 sample cutoff (having only 13 samples of which 4 contained in excess of 20 ppb), would show a 31% level of contamination. The fact that Richmond County is included in Tidewater supports the concept, but it was not counted. Also, when evaluating Figure 4, which involves all aflatoxin-positives, again it is seen that only two counties (possibly three), one in each of the two mid-quartiles, that are not in Tidewater.

In the summary data, it is seen that 97 counties grow corn with 79 submitting samples. Eighty one percent of the corn samples tested fell within FDA guidelines, meaning that they had less than 20 ppb. Also, 572 out of 997 or 57.4% had absolutely no aflatoxin detected in the corn. Falling within the Virginia limited-use guidelines were 96.8% of all samples tested. Essentially then, only 3.2% of the corn tested was not usable.

In looking at the breakdown of the contaminated corn samples, it is evident that 23.7% of the samples had between 0 and 20 ppb. From 21-100 ppb were found in 15.7% of all samples tested, decreasing to 2.9% for 101-400 ppb; and only 0.3% contained an excess of 400 ppb.

The following data is seen concerning counties with high levels of 101-400 ppb. Middlesex led the counties with 22%, Northumberland had 21.4%, Washington had 20%, King William had 11.8 and almost 6% had an even greater amount. Rounding out the top 10 counties in order are Halifax (8%), Richmond County (7.7%), Essex and Northampton (7.1%), Chesapeake City (5%), and Lancaster (4%). All of these counties but Northampton and Halifax are located in Tidewater while these two are located in the Southwest Mountain and Western Piedmont regions, respectively.

In comparison to other southern states as reported by Shotwell (1977), Virginia had a mild aflatoxin problem. However, when comparing previous samples in Virginia and the Midwest, Virginia did have a greater problem during the crop year 1977, therefore, it

appears that for that year, upon proceeding southward on a state by state basis, the more critical and the greater the aflatoxin problem became. This is substantiated by reports coming out of Georgia and Florida (Shotwell, 1977; Brown, 1978).

Virginia did have a problem in 1977 compared to its own base line in previous years. The primary parallel sequence that occurred, which may have contributed to this problem, was a slight, but not severe, drought followed by a wet fall (as measured by precipitation). Air temperature did not appear to be as important or deviate from normal. Probably during the drought, insect damage contributed to the problem, as has been noted in other areas by Lillehoj (1978). This idea by itself needs further study. Finally, it is of interest to note that aflatoxin levels in corn returned to normal in the crop year 1978, and as expected, the 1978 crop-year lacked the drought-wet sequence. Even though slight deviations with temperature were evident, it appears that the necessary temperature range was available to allow the mold to produce the toxin.

Although this paper primarily deals with the crop year 1977, further testing was done by the Department of Agriculture and Consumer Services for the next two crop years. Aflatoxin was found to be present in the corn during these terms, but it was in significantly lower amounts. Also, it should be noted that there was a change in the location of the aflatoxin problem during 1979 which may have been the result of a wet harvest period in that area.

During the 1978 crop year, out of 386 samples submitted, 286 or 74.1% contained no aflatoxin. Sixty samples or 15.54% contained 20 ppb, 29 (7.51%) contained 21-100 ppb, and 101-400 ppb aflatoxin were found in only 11 samples for a mere 2.85%.

Thirty five counties submitted 246 samples for the 1979 study. Only 19 samples were found to be contaminated; however, 15 of these were found from three Central Mountain counties (Augusta, Rockingham, and Shenandoah). Of the 15, 60% (9 samples) contained 0-29 ppb, 27% (4 samples) had 21-100 ppb, and in the remainder, no aflatoxin was found.

Regulatory officials, agribusinessmen, and farmers, therefore should be alert to a potential aflatoxin problem when the drought-wet sequence, occurring with normal summer temperatures becomes conducive to allow such a problem to develop. This seems especially relevant for the Tidewater region.

Acknowledgements

The authors appreciate the assistance provided by Mr. Hurtis Smith, U.S. Weather Service (National Oceanic and Atmospheric Administration) Byrd Field; Virginia Department of Agriculture and Consumer Services; and the Virginia Division of Consolidated Laboratory Services. Thomas Eadie was necessary and especially helpful in the completion of this study. He should rightfully be considered as a coauthor.

Literature Cited

- Brown, R. H. Favorable Conditions May Be Causing Spread of Aflatoxins. Feedstuffs, Sept. 12, 1978.
- Goldblatt, L. A., F. G. Doller. 1977. Review of Prevention, Elimination, and Detoxification of Aflatoxin. Pure & Appl. Chem. 49:1739-1764.
- Golumbic, C., M. M. Kulik. 1969. Fungal Spoilage in Stored Crops and Its Control. In Aflatoxins (L. A. Goldblatt, ed.), pp. 307-327. Academic Press (New York).
- Hesseltine, C. W. 1974. Natural Occurrence of Mycotoxins in Cereals. Mycopathol. Mycol. Appl. 53:141.
- Jensen, A. H., O. L. Brekke, G. R. Frank, A. J. Peplinski. 1977. Acceptance and Utilization by Swine of Aflatoxin-contaminated Corn Treated with Aqueous or Gaseous Ammonia. J. Animal Sci. 45:8-12.
- Lillehoj, E. B., A. Manwiller, J. A. DuRant, J. C. LaPrade, E. S. Horner, J. Reid, M. S. Zuber. 1976. Aflatoxin Production in Several Corn Hybrids Grown in South Carolina and Florida. Crop Sci. 16:483-485.
- Lillehoj, E. B. 1978. Use of Mycotoxin Contaminated Grain in the Ethanol Fermentation Process. Distillers Feed Research Council Conf. Proceedings. 33:23-29.
- Lillehoj, E. B., W. F. Kwolek, R. E. Peterson, O. L. Shotwell, C. W. Hesseltine. 1976. Aflatoxin Contamination, Fluorescence, and Insect Damage in Corn Infected with *A. flavus* Before Harvest. Cereal Chem. 53:505-512.
- Rambo, G. W., J. Turte, R. W. Caldwell. 1974. *Aspergillus flavus* and Aflatoxin in Preharvest Corn from Indiana in 1971 and 1972. Cereal Chem. 51:848-853.
- Romer, T. R. 1975. Screening Method for the Detection of Aflatoxin in Mixed Feeds and Other Agricultural Commodities with Subsequent Confirmation and Quantitative Measurement of Aflatoxin in Positive Samples. JAOAC. 58:500-506.
- Schooley, R. E., E. A. Finch. 1977. Virginia Agricultural Statistics. Virginia Coop. Crop Reporting Serv. Bull. 42. Richmond, Virginia. 50 pages.
- Shannon, G. M., O. L. Shotwell. 1978. Collaborative Study of Three Minicolumn Methods for Aflatoxin in Yellow Corn. Abstracts of the 92nd meeting of AOAC. p. 39.
- Shotwell, O. L., C. W. Hesseltine, H. P. Burmeister, W. F. Kwolek, G. M. Shannon, H. H. Hall. 1969. Survey of Cereal Grains and Soybeans for the Presence of Aflatoxin. II. Corn and Soybeans. Cereal Chem. 46:454.
- Shotwell, O. L., C. W. Hesseltine, M. L. Goulden, E. E. Vandergraff. 1970. Survey of Corn for Aflatoxin, Zearalenone, and Ochratoxin. Cereal Chem. 47:700.
- Shotwell, O. L., G. A. Bennett, M. L. Goulden, G. M. Shannon, R. D. Stubbefield, C. W. Hesseltine. 1978. Survey of 1977 Midwest Corn for Aflatoxin. Abstracts of the 92nd meeting of AOAC. p. 39.
- Shotwell, O. L., C. W. Hesseltine, M. L. Goulden. 1973. Incidence of Aflatoxin in Southern Corn, 1969-1970. Cereal Sci. Today. 18:192-195.
- Shotwell, O. L., C. W. Hesseltine, E. E. Vandergraff, M. L. Goulden. 1971. Survey of Corn from Different Regions for Aflatoxin, Ochratoxin, and Zearalenone. Cereal Sci. Today. 16:266.
- Shotwell, O. L. 1977. Aflatoxin in Corn. J. Amer. Oil Chemists' Soc. 54:216A-224A.
- Sledd, C. A., T. Eadie, C. E. O'Rear, G. C. Llewellyn. 1976. An Evaluation of Environmental Factors and Occurrence of Aflatoxin in Virginia Shelled Peanuts. Proc. Int. Biodegradation Symp., 3rd. pp. 625-634.
- Smith H. Sept., 1977. Meteorological Drought Summary in Virginia. U.S. Dept. of Commerce, National Oceanic and Atmospheric Admin., National Weather Ser. Richmond, Virginia.
- Spensley, P. C. 1963. Aflatoxin, The Active Principle in Turkey "X" Disease. Endeavor, 22:75-79.
- Ulloa-Sosa, M., H. W. Schroeder. 1968. Note on Aflatoxin Decomposition in the Process of Making Tortillas from Corn. Cereal Chem. 46:397-400.

Phrymaceae and Plantaginaceae in Virginia

Miles F. Johnson

Department of Biology
Virginia Commonwealth University
Richmond, Virginia 23284

Abstract—Phrymaceae (1 species) and Plantaginaceae (9 species) are studied floristically in Virginia. A new key to species of *Plantago* is provided. *Plantago wrightiana* is reported new to the Virginia flora and *Plantago cordata* is verified in the flora with specimen citations. Descriptions of all taxa, ecological data with dot maps, flowering and fruiting times and chromosome numbers, where known, are included.

Introduction

This paper is based upon field work and study of about 560 specimens from the following herbaria: George Mason University, Lynchburg College, Old Dominion University, University of North Carolina, U.S. National Herbarium, Virginia Commonwealth University, Virginia Polytechnic Institute and State University, West Virginia University, and the College of William and Mary. *Plantago cordata* was seen from the Missouri Botanical Garden, St. Louis, and from the New York Botanical Garden, Bronx, NY.

Phrymaceae, a monotypic family, occurs from India to Japan and in the eastern United States. It is represented in Virginia by *Phryma leptostachya*.

Plantaginaceae, consisting of three genera and about 270 cosmopolitan species, is represented in the Virginia flora by 9 species of *Plantago*.

Taxonomic Treatment

The Phrymaceae were placed taxonomically near Plantaginaceae in earlier works (Fernald, 1951; Gleason and Cronquist, 1963). More current work indicates a closer relationship with Verbenaceae (Takhtajan, 1969; Cronquist, 1968; Radford, et al., 1968) with the major distinguishing feature being the biovulate carpel in Verbenaceae vs. a single ovule in Phrymaceae.

Nomenclature follows Radford, et al. (1968) and Bassett (1966, 1967). Synonymy is not dealt with.

Phrymaceae

1. *Phryma leptostachya* L. Lop-Seed.

Perennial herb 2.2 - 9 dm tall, simple or less commonly branched; leaves opposite, thin, ovate, the largest or middle leaves (3.4-) 7.5 - 16 (-20.5) cm long, (2-) 3.1 - 8 (-9) cm wide (measurements include blade and petiole), crenate to doubly crenate, nearly glabrous, the apex often long attenuate; flowers borne on pedicels ca. 1 mm long in a raceme, buds erect, flowers horizontal or ascending, fruits strongly reflexed; sepals united, 2-lipped, the upper with three usually reflexed

triangular lobes, the lower with 2 lobes; corolla lavender, ca. 5 mm long, 2-lipped, the upper lip a single acute lobe, the lower 3 rounded lobes; stamens 4, included; ovary superior; fruit a single seeded nutlet, 7 - 8 mm long.

The species extends from New Brunswick on the north to east Texas on the south (Fernald, 1951) and is generally distributed throughout Virginia in damp woods (Fig. 1), less commonly in disturbed areas and is rarely associated with limestone. In addition to material examined in this study (Fig. 1) is reported from Giles County (Thorne and Cooperrider, 1960), Washington County (Jervis, 1969), Lee County (Carr, 1965) and from Accomack, Arlington, Amelia, Charles City, Northampton, Scott, Wythe Counties and the City of Virginia Beach. It is in flower and fruit from mid-June to late August (-late September).

Fernald (1950) reports var. *confertifolia* L. with gray puberulent leaves and simple margin teeth from eastern Virginia. The variety is not recognized in this study as the characters are not reliable; there are simple and double teeth on the same plant (Lewis, 1922, VPI).



FIG. 1—Distribution of *Phryma leptostachya* in Virginia. Dots indicate exact locations, squares indicate literature citations and open circles indicate a specimen seen without specific location data.

Plantaginaceae

1. *Plantago* L. Plantain.

Annual or perennial herbs. Leaves basal or opposite on branched stems. Spike scapose or axillary. Flowers hypogynous, actinomorphic, 4-merous; sepals united basally, petals united, the lobes erect, spreading or reflexed, membranous, persistent; stamens long exserted or not, anthers versatile; stigmas 2-cleft; capsule circumscissile, bilocular, 2 to many seeds.

Key to Species

- A. Caulescent, leaves linear, opposite, spike axillary 9. *P. psyllium*.
 AA. Acaulescent, leaves lanceolate to ovate, in basal rosettes, spike scapose B.
 B. Bracts subtending flowers (0.6-) 1 - 4 (-6) cm long, conspicuous; a taproot
 5. *P. aristata*.
 BB. Bracts subtending flowers shorter, inconspicuous; fibrous roots or a taproot C.
 C. Leaves ovate to elliptic, the largest 5 - 22 (-39) cm long, 2.5 - 8.5 (-10.5) cm wide, roots fibrous D.
 D. Lateral veins branching from mid-vein within tissue of blade, fibrous roots conspicuously thickened, aquatic or semi-aquatic habitat 1. *P. cordata*.
 DD. Lateral veins arising at base of blade from within petiole, fibrous roots slender, terrestrial habitats E.
 E. Largest leaves (8.5-) 10.5 - 25 (-39) cm long, 3 - 9 (-11.2) cm wide, petioles purple to red at base, fruit circumscissile near base 3. *P. rugelii*.
 EE. Largest leaves (5-) 8 - 14 (-22.5) cm long, 2.5 - 5.6 (-8.3) cm wide, petioles green at base; fruit circumscissile near middle 2. *P. major*.
 FF. Leaves linear to lanceolate to oblanceolate, generally shorter and more narrow than above F.
 F. Leaves linear, 1 - 2.5 mm wide, remotely toothed; 10 - 25 seeds per capsule; spikes loosely flowered 7. *P. heterophylla*.
 FF. Leaves wider, entire or rarely toothed; 2 seeds per capsule; spikes densely flowered G.
 G. Plants pubescent, leaves oblanceolate to elliptic; corolla lobes erect, forming a beak after flowering 6. *P. virginica*.
 GG. Plants glabrous to downy, leaves linear-lanceolate to narrowly elliptic to lanceolate; corolla lobes spreading to reflexed after flowering H.
 H. Leaves 5-veined, narrowly elliptic to lanceolate, (8.8-) 19.8 - 36 cm long, (3.3-) 4 - 31 (-65) mm wide, stamens long exserted, conspicuous; fibrous rooted 4. *P. lanceolata*.
 HH. Leaves 3-veined, linear-lanceolate, about 10 cm long, 5 mm wide, stamens not conspicuous; with a taproot 8. *P. wrightiana*.

1. *Plantago cordata* Lamarck

Acaulescent aquatic perennial with conspicuously thickened fibrous roots; leaves basal, broadly ovate to cordate-ovate, entire to remotely dentate, the largest (blade and petiole) 15.3 - 32 cm long, (3.5-) 7.5 - 10.5 cm wide, the lateral veins branching from the mid-vein within the leaf blade; spike 10 - 18 cm long, loosely flowered, scape 18 - 36 cm long; corolla lobes spreading after flowering, capsule circumscissile just below middle; 2 - 4 seeds. Chromosome number $2n = 24$ (Bassett, 1967).

The species extends from eastern Ontario south through Michigan and Illinois to Alabama and Florida (Bassett, 1967) but *P. cordata* may be extirpated from the State as the most recent collection occurred in 1902. Known from three collections: Alexandria: 1887, *Comstock s.m.* (NY); on bar extending into Potomac River at Alexandria Light, Aug. 13, 1902 (buds, flowers), *Shull 217* (MO, NY); Smyth Co.: Ravine of the Holston, June 8, 1892 (fruits), *Britton, Britton and Vail s.n.* (NY).

Plantago cordata is distinguished by the combination of veins branching from the mid-vein, the conspicuously fleshy roots and the semi-aquatic habitat.

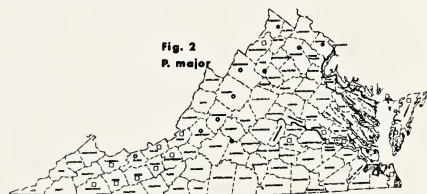


FIG. 2—Distribution of *Plantago major* in Virginia. Dots indicate exact locations, squares indicate literature citations, and open circles indicate a specimen seen without specific location data.

2. *Plantago major* L. Broad Leaf Plantain.

Acaulescent fibrous rooted perennial; leaves ovate to elliptic, the largest 4.8 - 22.5 cm long, (1.8-) 2.5 - 8.3 cm wide, entire to coarsely crenate, petioles green at base; scape 6 - 18 cm long; spike (7.5-) 9 - 19 cm long, remotely flowered below to densely so above; corolla lobes reflexed after flowering; capsule circumscissile near middle; 6 - 30 seeds. Chromosome number $n = 6$ (Radford, et al., 1968); $2n = 12$ (Löve, 1979).

Although *P. major* is a cosmopolitan weed, it is relatively uncommon in the state (Fig. 2) in fields and waste ground. In addition to those localities for which I have examined material (Fig. 2) it is reported from Giles County (Thorne and Cooperrider, 1960), and from Accomack, Charles City, Craig, Frederick, Giles, Henrico, James City, Montgomery, Northampton, Pulaski, Shenandoah, Smyth, Tazewell, and Wythe Counties and Virginia Beach (Massey, 1961). These specimens have not been seen in this study and I suggest that some of the Massey citations may indeed be

P. rugelii which is more common over the state.

Plantago major is in flower and fruit from early June through August. It is distinguished by the combination of large ovate leaves, green petioles and the fruit circumscissile near the middle.

3. *Plantago rugelii* Dene.

Similar to *P. major* but generally larger and more robust.

Leaves (8.6-) 10.5 - 40 cm long, (3-) 4.8 - 9 cm wide, entire, remotely toothed or coarsely lobed, conspicuously red to purple at petiole base; scape 8 - 30 cm long; spike (6-) 8.3 - 22 (-36) cm long, remotely to more commonly densely flowered; corolla lobes reflexed after flowering; capsule circumscissile below the middle; 4 - 10 seeds. Chromosome number $n = 12$ (Radford, et al., 1968); $2n = 24$ (Bassett and Crompton, 1968).

The species extends from Quebec to North Dakota and south (Fernald, 1950) and is general over the state along roadsides, in fields and woods, and more rarely along stream banks and in cultivated areas (Fig. 3). Jervis (1969) reports *P. rugelii* from Washington County, and Massey (1961) from Botetourt and Green Counties, but the vouchers for these citations have not been seen. It is in flower and fruit from July through mid-October.

Plantago rugelii is distinguished from *P. major*, which it closely resembles, by the combination of red petioles, the capsule circumscissile below the middle and the generally large size.

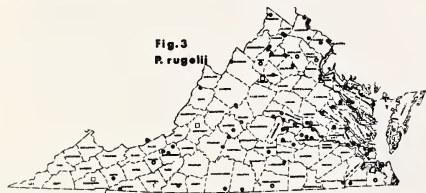


FIG. 3—Distribution of *Plantago rugelii* in Virginia. Dots indicate exact locations, squares indicate literature citations, and open circles indicate a specimen seen without specific location data.

4. *Plantago lanceolata* L. English Plantain; Buckhorn; Ripplegrass; Ribgrass.

Acaulescent perennial with fibrous roots; leaves narrowly elliptic to lanceolate, the longest (8.8-) 16 - 30 (-36) cm long, (0.3-) 0.9 - 3.7 (-6.5) cm wide, the 5 (-7) veins prominent; scape 17 - 65 cm long, slender; spike 2.8 - 5.2 (-6.9) cm long, slender, compact; stamens long exserted; corolla lobes spreading or reflexed after flowering; capsule circumscissile near the base; 2 seeds. Chromosome number $n = 6$ (Radford, et al., 1968); $2n = 12$ (Bassett and Crompton, 1968; Löve, 1979).

A common European native in the eastern United

States, it occurs generally throughout the state along roadsides, in yards, in fields, along railroads and in disturbed areas in general (Fig. 4) with the possible exception of the southwestern counties where it should be anticipated. It is in flower and fruit from mid-April to early October.

P. lanceolata is distinguished by the combination of prominently ribbed, lanceolate leaves and the compact spike borne on a long slender scape.



FIG. 4—Distribution of *Plantago lanceolata* in Virginia. Dots indicate exact locations, open circles indicate specimens seen without specific location data.

5. *Plantago aristata* Michx. Bracted Plantain.

Acaulescent, winter annual with a taproot; leaves filiform, linear to elliptic, the largest 12.5 - 15 cm long, 2 - 9 mm wide; scape (5-) 12 - 26 cm long; spike densely flowered, (0.2-) 2.8 - 15 cm long, bearing conspicuous linear to attenuate bracts (0.6-) 1 - 4 (-6) cm long; corolla spreading after flowering; capsule circumscissile near middle, seeds 2. Chromosome number $n = 10$ (Radford, et al., 1968); $2n = 20$ (Bassett and Crompton, 1968).

This species is common over the eastern United States (Fernald, 1950) and general over the state (Fig. 5) in old fields, pastures, on roadsides and railroad ballast and dry sandy soil. It is reported from Scott County (Massey, 1961); this voucher has not been seen. It is in flower and fruit from late May to early September.

The conspicuous bracts of the spike distinguish *P. aristata* in the genus. The taxon is extremely plastic; depauperate plants are found in sterile soil and fertile soil supports more robust growth.



FIG. 5—Distribution of *Plantago aristata* in Virginia. Dots indicate exact locations, squares indicate literature citations and open circles indicate a specimen seen without specific location data.

6. *Plantago virginica* L. Dwarf Plantain; Hoary or Pale Seeded Plantain.

White pubescent, acaulescent winter annual with taproot; leaves oblanceolate to elliptic, the largest (2.3-) 4.5 - 9.5 (-12) cm long, 0.8 - 2.8 (-3.4) cm wide, entire to remotely toothed; scape (2.5-) 5 - 20 (-23) cm long; spike densely flowered, at least above, (1.8-) 4 - 14 (-21) cm long; corolla erect and forming a tawny beak over the capsule after flowering; capsule circumscissile near middle, 2 seeds. Chromosome number $n = 12$ (Radford, et al., 1968); $2n = 24$ (Bassett and Crompton, 1968).

Relatively common over the continental United States (Fernald, 1950) and general throughout the state (Fig. 6) in fields, along roadsides and railroads, and in disturbed soil. It is reported from Amelia, Campbell, Scott, Shenandoah and Smyth Counties (Massey, 1961) but these vouchers have not been seen in the study. It is in flower and fruit from late March to early July and sporadically to early September.

Plantago virginica is distinguished by the white pubescent leaves and scapes and the conspicuous corolla beak over the mature capsule.

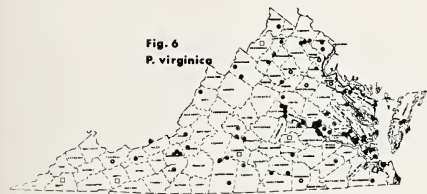


FIG 6—Distribution of *Plantago virginica* in Virginia. Dots indicate exact locations, squares indicate literature citations and open circles indicate a specimen seen without specific location data.

7. *Plantago heterophylla* Nutt.

Acaulescent, taprooted winter annual; leaves linear, the longest 3.5 - 4 (-5.5) cm long, 1 - 2.5 mm wide, entire to remotely toothed; scape (4.0-) 6.2 - 10.2 (-11.5) cm long; spike 2.2 - 5.1 cm long, the axis visible for most of the length in fruit; corolla lobes connivent around capsule after flowering; capsule circumscissile below the middle, 12 - 25 seeds. Chromosome number $n = 11$ (Radford, et al., 1968); $2n = 12$ (Bassett, 1966).

The species extends from Florida to California and north to Missouri, Illinois and Kentucky (Fernald, 1950) and southwestern Virginia (Fig. 7) in fallow and cultivated fields and in weedy areas. It is reported in Southampton County (Massey, 1961). It is in flower and fruit from mid-April through May.

Plantago heterophylla is distinguished by the linear leaves, loosely flowered spike and relatively small size of the plant.

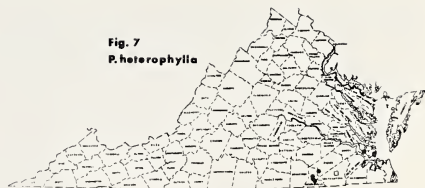


FIG 7—Distribution of *Plantago heterophylla* in Virginia. Dots indicate exact locations and the square indicates a specimen cited in the literature.

8. *Plantago wrightiana* Dcne.

Acaulescent, annual or winter annual with taproot; leaves linear to narrowly lanceolate, ca. 2X as long as wide; scapes stout, to 20 cm long, minutely pubescent; spikes densely flowered, to 5 cm long, the bracts broadly lanceolate to deltoid, the margin scarious about half the area of the bract; flowers perfect; corolla reflexed after flowering; capsule ca. 5 mm long, circumscissile near middle; seeds 2, ca. 3 mm long, olive brown (based on Kearney and Pebbles, 1951). Chromosome number $2n = 20$ (Bassett and Crompton, 1968).

Plantago wrightiana, indigenous to North America, ranges from South Carolina and Georgia west to Texas and Arizona (Bassett and Crompton, 1968) and is reported here initially as an element of the flora of Virginia: Mechenburg County: Seaboard Railroad track near Lake Gaston, June 24, 1967 (fl, fr), *Seaman 7099* (UNC).

This species is distinguished by the narrow leaves, large capsules and lanceolate to deltoid bracts.



FIG 8—Distribution of *Plantago psyllium* in Virginia. Dots indicate exact locations and the open circle indicates a specimen seen without specific location data.

9. *Plantago psyllium* L. Psyllium.

Caulescent, branched annual 1.8 - 4 dm tall, taprooted; leaves opposite, linear, 8 - 13 mm long, 3 - 4.5 mm wide, firm; spikes axillary, compact, 8 - 13 mm long; corolla reflexed after flowering; capsule circumscissile near base, seeds 2. Chromosome number $2n = 12$ (Bassett and Crompton, 1968).

P. psyllium is scattered over the eastern United States and adjacent Canada from Quebec to Minne-

sota and south to Illinois, Indiana, Ohio and Virginia (Fernald, 1950). It is rare in the State, known from four counties (Fig. 8) where it occurs in railroad ballast and on the VPI & SU campus. It is in flower and fruit from late June through August.

Plantago psyllium is distinguished by its caulescent and branched habit.

Literature Cited

- Bassett, I. J. 1966. Taxonomy of North American *Plantago* L., Section *Micropsyllium* Decne. Can. J. Bot. 44: 467 - 479.
- _____. 1967. Taxonomy of *Plantago* L. in North America, Sections *Holopsyllium* Pilger, *Palacopsyllium* Pilger and *Lamprosantha* Decne. Can. J. Bot. 45: 565 - 577.
- _____. and C. W. Crompton. 1968. Pollen Morphology and Chromosome Numbers of the Family Plantaginaceae in North America. Can. J. Bot. 46: 349 - 361.
- Carr, L. G. K. 1965. Floristic Elements in Southwestern Virginia—A Phytogeographical Consideration. Castanea 30: 105 - 145.
- Cronquist, A. 1968. The Evolution and Classification of Flowering Plants. Houghton Mifflin Co., Boston. 396 p.
- Fernald, M. L. 1950. Gray's Manual of Botany, 8th ed. American Book Co., New York. 1632 p.
- Gleason, H. A. and A. Cronquist. 1963. Manual of the Vascular Flora of Northeastern United States and Adjacent Canada. D. Van Nostrand Co., Princeton. 810 p.
- Jervis, R. A. 1969. Additions to the Flora of Washington County and Southwestern Virginia. Castanea 34: 99 - 121.
- Kearney, T. H. and R. H. Peebles. 1960. Arizona Flora, 2nd edition with supplement. University of California Press, Berkeley, 1085 p.
- Löve, A. 1979. IOBP Chromosome Number Reports LXX. Taxon 28 (4): 627 - 637.
- Massey, A. B. 1961. Virginia Flora. Va. Agr. Sta. Tech. Bull. 155, Blacksburg. 258 p.
- Radford, A. E., H. E. Ahles and C. R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. University of North Carolina Press, Chapel Hill. 1183 p.
- Takhtajan, A. 1969. Flowering Plants, Origin and Dispersal. Oliver and Boyd, Edinburgh. 310 p.
- Thorn, R. F. and R. S. Cooperrider. 1960. The Flora of Giles County, Virginia. Castanea 25: 1 - 53.

Distribution and Composition of the Macrophyte Community in Mountain Lake, Virginia

Charles E. Dubay

409 Skipjack Road
Newport News, Virginia 23602

and

George M. Simmons, Jr.

Department of Biology,
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

Abstract—The distribution and composition of a macrophyte community in a montane, oligotrophic lake is described. *Nitella flexilis* (L.) Ag was the dominant species and its distribution was based on substrate characteristics and degree of basin slope. This species was most common in sediment with a high organic content and grew best on moderate/gentle slopes. A morphologically similar species, *Chara braunii*, was prevalent in shallow areas and was common particularly in those areas that have been enriched by sand. The presence of both species represents new published state records for Virginia.

Introduction

Mountain Lake, located at an elevation of 1180 m on top of Salt Pond Mountain near Pembroke, Virginia, occupies one of two natural lake basins in Virginia. The basin is oriented in general north-south direction and is 870 m long by 255 m wide (Figure 1) (Roth and Neff, 1964). The Mountain Lake Hotel maintains a swimming area and boat dock at the lake's south end for hotel guests.

Several limnological studies have been made of this montane oligotrophic lake (Hutchinson and Pickford, 1932; Coker and Hayes, 1940; Roth and Neff, 1964; Marland, 1967; Obeng-Asamoah and Parker, 1972; Simmons and Neff, 1973; Parker, Wolfe and Howard, 1975; and Simmons, 1975). Most of these studies concentrated on the lake's physical-chemical properties, history, or productivity of the limnetic phytoplankton community. Dubay and Simmons (1979) studied the macrophyte community's relationship to the lake's strong metalimnetic oxygen maximum. In the course of describing the standing crop and biomass distribution within the lake basin, a very comprehensive list of macrophytes known to exist within the lake was also compiled.

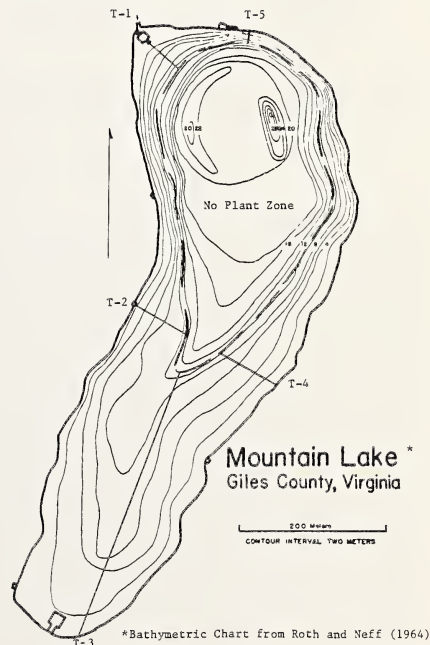


FIG. 1.—Bathymetric map of Mountain Lake with transect positions.



FIG. 2—Taxonomic characteristic of *Chara* and *Nitella* (Reproduced from Wood, 1967 by permission of Mrs. R. D. Wood).

The Problem

One of the lake's most interesting properties is the extensive and dense beds of rooted macrophytes which exist in the littoral zone. Even though Forest (1954), Roth and Neff (1964) and Obeng-Asamoah (1971) listed *Nitella flexilis* as the dominant macrophyte, there has been some controversy between biologists who have studied the lake (unpublished) over which macrophyte, *Chara braunii* or *Nitella flexilis*, was most abundant in the lake, or, in fact, if there were only one species. Both belong to the family Characeae and exhibit similar growth forms. For example, *C. braunii* Gm. (Fig. 2, No. 3), like *N. flexilis* (L.) Ag. (Fig. 2, No. 5), lacks the extra layer of "cortex" cells (Fig. 2, No. 4) which cover the "stem" and "branchlets" of all other North American species of *Chara*. However, in *Chara* the "branchlets" are simple (Fig. 2, No. 1) while *Nitella* branchlets are further subdivided (Fig. 2, No. 2). *Chara* is further characterized by the presence of stipule-like structures (stipulodes) which hang down from each node (Fig. 2, No. 6). These structures are lacking in *Nitella* (Fig. 2, No. 5). The oogonia in *Chara* are crowned with a single tier of five coronula cells (Fig. 2, No. 3) while the corresponding structures of *Nitella* possess a double tier composed of ten coronula cells (Fig. 2, No. 8). In certain cases where *N. flexilis*

(L.) Ag., which is usually monoecious (Fig. 2, No. 7), occurs in a dioecious condition (Fig. 2, No. 5), it can further be distinguished from *C. braunii* Gm. in which all reproductive specimens are monoecious (Wood, 1967).

We present here the results of our study on the species and biomass distribution pattern for the macrophyte community in Mountain Lake.

Methods and Materials

Benthic macrophytes were quantitatively collected along five underwater transects (N, S, E, and W, Fig. 1) during July and August 1973. The samples were collected by divers using SCUBA and a hand-operated 15.2 × 15.2 cm Ekman dredge. This procedure eliminated mechanical sampling error and ensured the removal of samples from precise depths. Each transect was sampled at the surface and 1-m depth intervals to 11 m, beyond which no macrophytes occurred. Five replicate samples were obtained from each depth on each transect for a total of 300 samples. Replicate samples at a given depth were separated by distances of approximately 1 m. Transect 1 was used for a pilot study.

Each sample was placed in labeled plastic bags in the field. In the laboratory, the plant material was separated from the soil by washing in a no. 35 mesh sieve (500 μ mesh openings). Samples were then preserved by freezing and washed at a later time following the procedure described by Westlake (1969). All samples were examined under a stereomicroscope for extraneous material and then rinsed in 0.12 N HCl to remove any possible adhering carbonate. The samples were then dried (105 C for 24 hr) and ashed (500 C for 5 hr) according to methods of Westlake (1969) and American Public Health Association *et al.* (1971), respectively. Data are reported as ash-free dry weights/m².

Light penetration was measured with a Whitney photometer (model No. LMD8A-Motodore Corporation). The per cent grade of each transect slope was determined from the planimetric map of Roth and Neff (1964). Substrate composition was evaluated by visual observation.

Results and Discussion

We found 39 macrophyte species distributed through 22 families (Appendix 1). Most species were very low in numbers and restricted to only a few locations in very shallow water. Only five species were collected by dredge along the transects: (1) *Fontinalis novae-angliae* Sull., (2) *Chara braunii* Gm., (3) *Anacharis canadensis* (Michx.) Rich., (4) *Ceratophyllum demersum* L., and (5) *Nitella flexilis* (L.) Ag. In an oligotrophic Michigan lake, Rich, Wetzel and Thuy (1971) found 23 species (3 charophytes, no bryophytes, and 20 vascular plants) distributed through nine families.

Table I. - Mean ash-free dry weights (gms m⁻²) for the dominant summer macrophyte species at each meter depth on all transects of the littoral zone and the total sample weight of each macrophyte in Mountain Lake, Virginia--July, 1973.

Depth (m)	<u>Fontinalis novae-angliae</u> Suill.	<u>Chara braunii</u> Gm.	<u>Anacharis canadensis</u> (Michx.) Rich.	<u>Ceratophyllum demersum</u> L.	<u>Nitella flexilis</u> (L.) Ag.	\bar{X} combined macrophyte weight (gm m ⁻²)
0	73.83	.66	.03	0	.02	14.91
1	15.37	.94	.04	0	17.95	6.86
2	.17	0	.44	0	30.66	6.25
3	0	0	3.10	0	40.15	8.64
4	0	0	9.57	21.55	54.61	17.15
5	0	0	3.21	0	145.02	29.65
6	0	0	2.30	0	356.20	71.70
7	0	0	0	0	177.67	35.54
8	0	0	0	0	130.87	26.17
9	0	0	0	0	148.04	29.61
10	.01	0	0	0	76.07	15.22
11	0	0	0	0	.14	.03
Total*	89.38	1.60	18.74	21.55	1177.40	

*Total reflects the total sample weight of each macrophyte species.

Table II - Percent of sample ash-free dry weight occupied by each of the 5 rooted macrophytes collected from 5 transects combined in Mountain Lake, Virginia--July, 1973.

Depth (m)	<u>Fontinalis novae-angliae</u> Suill.	<u>Chara braunii</u> Gm.	<u>Anacharis canadensis</u> (Michx.) Rich.	<u>Ceratophyllum demersum</u> L.	<u>Nitella flexilis</u> (L.) Ag.
0	99.05	.89	.03	0	.03
1	44.82	2.47	.12	0	52.32
2	.54	0	1.42	0	98.04
3	0	0	7.15	0	92.85
4	0	0	11.16	25.14	63.70
5	0	0	2.16	0	97.84
6	0	0	.64	0	99.36
7	0	0	0	0	100.00
8	0	0	0	0	100.00
9	0	0	0	0	100.00
10	.02	0	0	0	99.98
11	0	0	0	0	100.00
Total	6.83	.12	1.43	1.65	89.97

Frantz and Cordone (1967) found 19 species (2 charophytes, 4 filamentous algae, 13 bryophytes, and no vascular plants) distributed through eight families in ultra-oligotrophic Lake Tahoe. Wilson (1937) found only 27 species of vascular plants distributed through 18 families in a eutrophic Wisconsin lake. It is not uncommon to find the macrophyte community to be both rich in species numbers and biomass in oligotrophic lakes. Such plants are intimately associated with sediment from which they can obtain necessary nutrients (Pearsall, 1920; Wetzel, 1975) and the clear water allows deep-water growth to the compensation point. Pressure at depth is often limiting for higher plant species, which possess gas-filled lacunae, but not for lower macrophytes, such as bryophytes or charophytes (Hutchinson, 1975).

The mean biomass distribution of the five dominant species with depth is presented in Table I. The dominant macrophyte in Mountain Lake is *N. flexilis* and

comprised almost 90% of the lake's standing crop (Table II). According to Choudhary and Wood (1973), *N. flexilis* has not previously been reported for the State of Virginia. *Nitella*'s toleration for reduced light levels (Daily, 1959) and fine silted substrate (Daily, 1959; Pearsall, 1920) allow it to grow well in Mountain Lake's littoral zone. The maximum biomass of this species occurred below four meters where it comprised approximately 99% of the standing crop (Table II). Although *Nitella* is reported to survive at low light intensities 0.3% of surface light (Frantz and Cordone, 1967), we found its growth to stop at 11 meters which closely corresponded to 1% of surface light levels (Fig. 3). The distribution pattern of this species around the lake indicated that it grew best on the north facing slope which had the most gradual slope (Fig. 1; Table III). Moreover, *Nitella* did not grow well in areas where there was a reduction of organic content in the sediment.

Table III.- Combined standing crop ash-free dry weights (gms m⁻²) and total ash-free dry weight of the rooted macrophytes on each of 5 transects in Mountain Lake, Virginia--July, 1973.

Depth (m)	Transect 1 (East-facing)	Transect 2 (East-facing)	Transect 3 (North-Facing)	Transect 4 (West-facing)	Transect 5 (South-facing)	\bar{X} combined macrophyte weight (gm m ⁻²)
0	.01	27.75	45.90	.81	.07	14.91
1	3.50	14.95	15.86	0	0	6.86
2	.14	6.43	20.69	1.29	2.73	6.25
3	6.96	9.16	14.41	10.73	1.93	8.64
4	15.14	15.81	46.51	6.96	1.30	17.15
5	22.36	39.63	22.57	47.96	15.71	29.65
6	44.23	73.66	183.70	42.91	14.00	71.70
7	25.58	33.20	27.29	32.48	59.12	35.54
8	47.70	27.10	18.58	30.29	7.20	26.17
9	25.17	65.85	13.37	18.79	24.86	29.61
10	21.29	46.32	3.55	2.56	2.36	15.22
11	0	.002	0	0	.13	.03
Total*	212.08	359.86	412.43	194.78	129.41	
% Grade	13.8	13.8	2.9	12.4	61.0	

*Total reflects the total plant weight for each transect.

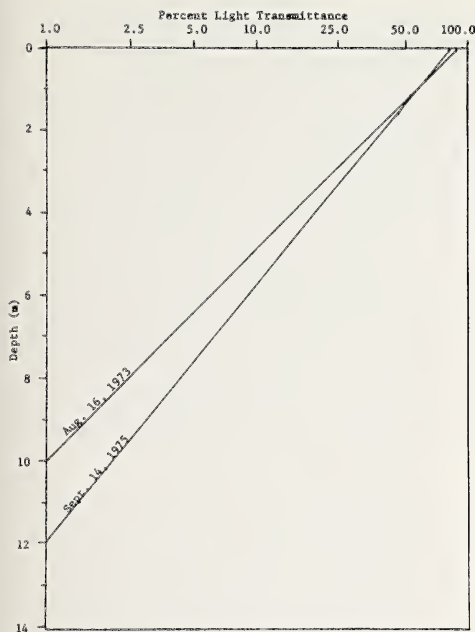


FIG. 3.—Unfiltered light transmission at noon in Mountain Lake, Virginia.

Chara braunii was sparsely represented and restricted to the shallow southern end of the lake (Tables I and II). The limited distribution of this species appears to be due to its requirement for a quartz sand substrate (Shen, 1971) with low organic content (Proctor, 1967). The sandy beach area around the boat dock would meet both requirements. The presence of *C. braunii* also appears to represent another new state record for Virginia (Choudhary and Wood, 1973).

Anacharis canadensis was distributed around the lake's basin to a depth of six meters. The fact that it does not grow deeper is not surprising since Hutchinson (1975) reported that such higher macrophytes with lacunae are often depth limited by pressure. *Ceratophyllum demersum* was found only along Transect 3 at four meters. Our inability to relocate this population two years after the initial study may indicate that these plants are unattached and drift near the substrate as reported by Hutchinson (1975). The bryophyte, *F. novae-angliae*, was found only below 2 m usually growing on rocks and logs. This bryophyte has been recorded from depths of 13–20 m in certain clear Wisconsin lakes (Juday, 1934) where the water was oligotrophic (secci = 13 m).

Summary

The macrophyte community of Mountain Lake is very rich in both the number of families and species represented. Two new state records have been determined and our study showed that *N. flexilis* is the dominant macrophyte in the lake. *Chara braunii* occurs in the lake, but is limited to the very shallow sandy area immediately to the west of the boat house at the lake's south end. Since this is the end frequented by hotel guests and scientists alike, and the area is enriched by sand additions for swimming purposes, it is easy to understand why it could previously have been construed that *C. braunii* was the lake's dominant littoral species. *C. braunii*, however, is not as well adapted as *N. flexilis* for the substrate conditions that prevail in Mountain Lake. *Nitella flexilis* concomitantly is absent from the shallow areas where it would be easily missed by collectors wading near shore.

References Cited

- American Public Health Association, American Water Works Association, Water Pollution Control Federation (1971): Standard Methods for the Examination of Water and Waste Water. 13th ed. 874 p., Washington, D.C.
- Choudhary, M. C. and R. D. Wood (1973): The Characeae of Southeastern United States. *Amer. Midl. Nat.* 90, 413–446.
- Coker, R. E. and Hayes, W. J., Jr. (1940): Biological Observations in Mountain Lake, Virginia. *Ecol.* 21, 192–198.
- Daily, F. K. (1959): Some Observations on the Occurrence and Distribution of the Characeae of Indiana. *Proc. Indiana Acad. Sci.* 68, 95–107.
- Dubay, Charles I. (1976): The Standing Crop and Distribution of Macrophytes in Mountain Lake, Virginia, with Particular Emphasis on the Contribution of *Nitella flexilis* (L.) Ag. to the Metalimnetic Oxygen Maximum. Master Thesis. University of Virginia. 97 pp.
- Dubay, Charles I. (1977): The Use of Underwater Research Equipment in Temperate Lakes and Reservoirs. In *The Use of Underwater Equipment in Freshwater Research* (G. M. Simmons, Jr., ed.), Sea Grant, VPI & SU, VPI-SG-77-03. 66 p.
- Dubay, C. I. and Simmons, G. M., Jr. (1979): The Contribution of Macrophytes to the Metalimnetic Oxygen Maximum in a Montane, Oligotrophic Lake. *Amer. Midl. Nat.* 101, 108–117.
- Forest, H. S. (1954): Checklist of Algae in the Vicinity of Mountain Lake Biological Station, Virginia. *Castanea*, 19, 88–104.
- Frantz, T. C. and Cordone, A. J. (1967): Observations on Deepwater Plants in Lake Tahoe, California and Nevada. *Ecol.* 48, 709–714.
- Gleason, H. A. and Cronquist, A. (1963): *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. 810 p. D. Van Nostrand Company, Inc., Princeton.
- Hutchinson, G. E. and Pickford, G. E. (1932): Limnological Observations on Mountain Lake, Virginia. *Int. Rev. Hydrobiol.* 27, 252–264.
- Hutchinson, G. E. (1975): *A Treatise on Limnology. Vol. III: Limnological Botany*. 660 p. John Wiley and Sons, Inc., New York.
- Juday, C. (1934): Notes and Comments on the Depth Distribution of Some Aquatic Plants. *Ecol.* 15, 325.

Marland, F. C. (1967): The History of Mountain Lake, Giles County, Virginia: An Interpretation Based on Paleolimnology. Unpub. Doctoral Dissert., Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Obeng-Asamoah, E. K. and Parker, B. C. (1972): Seasonal Changes in Phytoplankton and Water Chemistry of Mountain Lake, Virginia. *Trans. Amer. Microsc. Soc.* 91, 363-380.

Parker, B. C., Wolfe, H. E., and Howard, R. V. (1975): On the Origin and History of Mountain Lake, Virginia. *Southeastern Geol.* 16, 213-226.

Pearsall, W. H. (1920): The Aquatic Vegetation of the English Lakes. *J. Ecol.* 8, 163-201.

Rich, P. H., Wetzel, R. G. and Thuy, N. V. (1971): Distribution, Production and Role of Aquatic Macrophytes in a Southern Michigan Marl Lake. *Freshwater Biol.* 1, 3-21.

Roth, J. C. and Neff, S. E. (1964): Studies of Physical Limnology and Profundal Fauna, Mountain Lake, Virginia. *Va. Agric. Exp. Stn. Tech. Bull.* 169, 44 pp.

Simmons, G. M., Jr. and Neff, S. E. (1973): Observations on Limnetic Carbon Assimilation Rates in Mountain Lake, Virginia During Its Thermal Stratification Periods. *Va. J. Sci.* 24, 206-211.

Simmons, G. M., Jr. (1975): Observations on Limnetic Carbon Assimilation Rates in Mountain Lake, Virginia: A Correction. *Va. J. Sci.* 26, 135.

Westlake, D. E. (1969): Macrophytes. In *A Manual on Methods Measuring Primary Production in Aquatic Environments* (R. A. Vollenweider, ed.), pp. 25-32. IBP Handbook No. 12, Blackwell Scientific Publications, Ltd., Oxford.

Wetzel, R. G. (1975): *Limnology*, 743 p., W. B. Saunders Company, Philadelphia.

Wilson, L. R. (1937): A Quantitative and Ecological Study of the Larger Aquatic Plants of Sweeney Lake, Oneida County, Wisconsin. *Bull. Torrey Bot. Club* 64, 199-208.

Wood, R. D. (1967): *Charophytes of North America*. Stella's Printing, West Kingston, R.I. 72 pp.

Appendix I.—List of macrophytes growing in Mountain Lake, Giles County, Virginia, 1973-1975.

I. ALGAE: (Nomenclature according to Wood, 1967)

CHARACEAE: *Chara braunii* Gm., *Nitella flexilis* (L.) Ag.

II. BRYOPHYTES: (Nomenclature according to Conard, 1956)

A. Mosses (Musci):

FISSIDENTACEAE: *Fissidens bryoides* Hedw.; *Fissidens hallianus* (Sull. and Lesq.) Mitt.

MNIACEAE: *Mnium punctatum* Hedw.

HYPNACEAE: *Brachythecium rivulare* B. S. G.; *Climacium americanum* Brid.; *C. Kindbergii* (Ren. & Card.) Grout; *Hygrohypnum eugyrium* (B. S. G.) Loeske; *Leptodictyum riparium* (Hedw.) Warnst

FONTINALACEAE: *Fontinalis novae-angliae* Sull.

B. Liverworts (Hepaticae):

HARPANTHACEAE: *Chiloscyphus pallescens* (Ehrh.) Dum.

PLAGIOCHILACEAE: *Plagiochila asplenoides* (L.) Dum.

SCAPANACEAE: *Scapania undulata* (L.) Dum.

PORELLACEAE: *Porella pinnata* L.

RICCARDIACEAE: *Riccardia latifrons* Lindb.

III. VASCULAR PLANTS: (Nomenclature according to Gleason and Cronquist, 1963)

EQUISETACEAE: *Equisetum arvense* L.

ISOETACEAE: *Isoetes engelmannii* A. Br.

POTOMOGONTONACEAE: *Potamogeton spirillum* Tuckerm.

ALISMACEAE: *Alisma plantago-aquaticum* L.

HYDROCHARITACEAE: *Anacharis canadensis* Michx.; *A. nuttallii* (Planch.) St. John

CYPERACEAE: *Carex baileyi* Britt.; *C. crinita* Lam.; *C. frankii* Kunth; *C. scoparia* Schk.; *Eleocharis obtusa* (Willd.) Schultes; *E. palustris* (L.) R. & S.

JUNCACEAE: *Juncus acuminatus* Michx.; *J. brevicaudatus* (Engelm.) Fern.; *J. bufonius* L.; *J. effusus* L.; *J. marginatus* Rostk.; *J. tenuis* Willd.

SALICACEAE: *Salix sericea* Marsh.

POLYGONACEAE: *Polygonum scandens* L.

CERATOPHYLLACEAE: *Ceratophyllum demersum* L.

CALLITRICHACEAE: *Callitriche heterophylla* Pursh.

HYPERICACEAE: *Hypericum mutilum* L.

Vascular Flora and Vegetation of the Kent Branch Watershed, Fluvanna County, Virginia¹

George M. Diggs, Jr.² and Gustav W. Hall

Department of Biology
College of William and Mary
Williamsburg, Virginia 23185

Abstract—The Kent Branch Watershed is a fourteen square mile area located in north-central Fluvanna County, Virginia. This county is located in the central Piedmont of Virginia, north of the James River, about 30 miles east of the Blue Ridge Mountains. Collections of the vascular flora began in March of 1975 and continued until July of 1976. A total of 752 species were collected including 733 new to Fluvanna County.

Major plant communities of the area were studied both qualitatively and, where applicable, quantitatively using the Bitterlich method of forest sampling.

Introduction

The Kent Branch Watershed comprises approximately 14 square miles of rolling terrain in the central Piedmont of Virginia. The area essentially includes the whole watershed of Kent Branch to its confluence with Venable Creek to form Byrd Creek, a tributary of the James River.

There are many mountain-Coastal Plain disjuncts in Virginia and more work in the Piedmont is needed to clarify whether at least some of these are collecting artifacts. The reason for this is that much more extensive collecting has been done in the mountains and on the Coastal Plain than in the intervening Piedmont. Botanical work has been done in the southern Piedmont by Hathaway, Harvill, Ramsey, Stevens, and others, and floristic work has also been carried out in the northern Piedmont by such botanists as Allard, Bradley, Leonard, and Mazzeo, but there exists a serious need for comprehensive floristic studies of Piedmont counties. Thus the Piedmont location was the first consideration in the selection of the study area, and a Fluvanna County (Figure 1) locality was then chosen because of the specific need for floristic work in that county. No extensive botanical work has been done in Fluvanna County prior to this study, although limited collecting has been done from time to time in Fluvanna by Virginia botanists such as Charles E. Stevens and Thomas F. Wieboldt. Published records of the flora of Fluvanna County are rare.

Methods

Collection of specimens of the vascular flora of the Kent Branch Watershed began in March 1975 and continued through July 1976. Collecting trips were taken on an average of once weekly during the growing season. Habitat and abundance data for each taxon are based on collection data and personal observation.

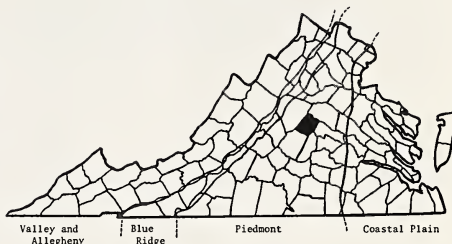


FIG. 1.—Location of Fluvanna County in the Piedmont of Virginia.

Nomenclature for specific and subspecific taxa follows that of Radford, Ahles, and Bell (1968).

Determination of county, northern Piedmont (north of the James River), and Piedmont distributional records is based on the works of Allard and Leonard (1943, 1944, 1952, 1962), Bradley (1972, 1973), Gilman (1957), Grimshaw and Bradley (1973), Harvill (1973b), Hathaway and Ramsey (1973), Johnson (1970, 1971a, 1971b, 1972a, 1972b, 1974a, 1974b, 1974c), Lewis (1958), Massey (1961), Mazzeo (1972), Nessler (1976), Ramsey (1967), Ramsey et al. (1969), Roane (1975), Roe (1977), Smith (1976), and Thacker et al. (1968).

A vegetational study of the area was conducted, and quantitative data obtained for a number of diverse forest stands. Stands were subjectively selected for quantitative sampling as being representative of important community types in the study area. Dominance was measured (in square meters per hectare, cross-sectional area breast high) by the Bitterlich method (Beers and Miller 1964), using a Spiegel Relaskop (angle gauge). Relative dominance for each

Footnotes

¹Based on a Master's thesis submitted to the College of William and Mary, Williamsburg, Virginia, and funded in part by that institution. The authors would like to thank Dr. Donna M. E. Ware, for her generous assistance, Dr. Stewart A. Ware, for his contributions on the ecological aspects, and Dr. A. M. Harvill, Jr. of Longwood College for his verification of many specimens of the Monocotyledoneae.

²Present address: Dept. of Botany, University of Wisconsin-Madison, Madison, Wisconsin 53706.

species was calculated by dividing the measured dominance for that species by the sum of the dominance for all species in the stand. The density of each species (in trees per hectare) was based on counts of stems with a diameter at breast height of four inches or greater found in circular plots with a radius of ten meters (32.8 feet). Relative density was determined as was relative dominance and an average of these two values was taken as the relative importance value (I.V.).

Soil samples (Table 1), taken at random from all of the forest stands measured, were obtained on May 20, 22, and 23, 1976. Samples were taken from several points in each stand, combined, and analyzed for Ca, Mg, K, pH, and salt concentration by the Virginia Truck and Ornamentals Research Station, Norfolk, Virginia.

TABLE 1. Results of Soil Analysis^a.

Stand	pH	Calcium ^b	Magnesium ^b	Potash ^b	Salt Conc. ^c
1	4.7	1093	416	227	64
2	4.5	d	292	493	69
3	4.0	d	52	265	69
4	4.6	d	132	137	64
5	4.6	d	120	115	62
6	4.8	1188	416	300	60
7	4.6	1188	416	161	58
8	4.6	336	488	3158	107

^aAnalysis by Virginia Truck and Ornamentals Research Station, Norfolk.

^bIn lbs. oxide/acre

^cIn parts per million

^dNot determined

Geology

Fluvanna County is situated on the southeastern limb of the Blue Ridge Anticlinorium and is located entirely within the Piedmont physiographic province (Smith et al. 1964). The surface features are in general those of a moderately high plateau dissected by numerous streams (Porter 1958). The total relief of the study area, located in north-central Fluvanna County, is 270 feet, ranging from a high of 530 feet near the Fluvanna-Louisa County line in the north to a low of 260 feet along Kent Branch at the southern tip of the watershed (U.S. Geological Survey 1970). The drainage pattern of the Kent Branch Watershed, like most others in Fluvanna, is dendritic. This reflects the homogeneity of the parent material in its response to weathering. Since the area has a generally warm and moist climate, chemical weathering is very active. A deep layer of rock residuum has developed over almost all uplands in the area and this indicates extensive weathering (Smith et al. 1964).

The underlying rocks of the country range from the Cambrian or Precambrian Catoctin Formation through the Upper Ordovician Arvonian Formation. The sequence is largely faulted and folded volcanic and sedimentary rocks that have undergone low to medium grade metamorphism and have been intruded by Triassic diabase dikes. One important formation exposed in northeastern Fluvanna is a metamorphosed volcanic and sedimentary rock unit of Ordovician age. This unit is composed primarily of gneiss, schist, phyllite, and quartz-feldspar rocks. Another formation exposed in the study area is a medium to coarse-grained granodiorite unit probably intruded around 400 million years ago (Smith et al. 1964).

The parent materials present have weathered into a variety of soil types depending on such factors as slope and age. In many areas of the county, sheet erosion has been so severe that significant areas of land surface have been stripped of soil layers, sometimes down to the parent material (Porter et al. 1958).

Among the important soil series found in Fluvanna County are the Tatum and Nason series on the uplands, the Manteo series in areas of steep relief, and the Congaree and Mixed Alluvial series on bottomlands (Porter et al. 19658). Soil differentiation is dependent to a certain extent on factors such as moisture and slope, and these conditions, along with mineral availability and pH, control the presence of certain plant associations. An example is seen on the bluffs along Kent Branch. Here the moisture and edaphic conditions favor the existence of a characteristic plant association including *Polypodium virginianum*, *Thalictrum thalictroides*, *Hepatica americana*, *Cimicifuga racemosa*, and *Arabis canadensis*.

The type of climax community present in a given area also seems to be partially determined by the soil series and other edaphic factors present. A good example is the greater structural importance of *Quercus prinus* on rocky soils and on soil series characterized by excessive drainage. This is further discussed in the section dealing with vegetational patterns.

Climate

Due to its location in the central Virginia Piedmont, the climate of Fluvanna County is continental. Temperatures and rainfall are relatively uniform throughout the county because of the lack of modification by large bodies of water or mountains. The average growing season is 186 days, extending from April 17 (average date of last killing frost) to October 20 (average date of first killing frost). The average annual temperature is 56.3°F (Porter et al. 1958).

Rainfall, as a general rule, is evenly distributed throughout the year with slightly more in the spring and summer. The average annual rainfall in Fluvanna County is 44.24 inches (Porter et al. 1958).

Past climatological conditions may have played an important role in determining the floristic composition

of many Piedmont communities. According to Harvill (1973a), the xerothermic period of post-glacial times may have significantly affected the Piedmont vegetation. Many species probably survived this period of stress only in special edaphic and hydrologic situations. The lack of such situations, including bogs, sandy areas, and limestone-derived soils in the Piedmont, is significant in this respect. This could possibly explain both the present absence of many plants from apparently suitable habitats and the many interesting disjunctions and other distributional problems now seen in the flora of Virginia (Harvill 1973a).

Vegetational Patterns

As would be expected in a study area of this size (fourteen square miles), there is a great deal of vegetational diversity in the Kent Branch Watershed. The major plant communities present include: 1) upland woods—subdivided into deciduous woods, mixed pine-deciduous woods, and pine woods 2) bottomland woods 3) freshwater lakes and marshes 4) early old field successional areas and 5) recently disturbed areas. Each of these major community types can be broken down into subdivisions that are very different from both structural and functional standpoints.

Table 2. Total Dominance, Total Density, and Species Importance Values for the species in each stand.

Tree Species	Stand Number ^a							
	1	2	3	4	5	6	7	8
<i>Acer rubrum</i>	9.47%	1.00%	12.28%	0.99%	6.50%		26.45%	26.50%
<i>Betula nigra</i>							7.96	
<i>Carpinus caroliniana</i>					1.07		20.66	27.44
<i>Carya glabra</i>		8.84	5.59	4.99				
<i>Carya ovata</i>		2.81						
<i>Carya tomentosa</i>	4.23	1.81	1.43	1.52				
<i>Cornus florida</i>				0.99	2.99		1.92	
<i>Fraxinus americana</i>	7.24							
<i>Fraxinus pennsylvanica</i>								5.78
<i>Fraxinus</i> ssp.					1.48		3.87	
<i>Juniperus virginiana</i>	8.81					6.44%		
<i>Liquidambar styraciflua</i>	6.46			8.48	8.73		7.45	17.94
<i>Liriodendron tulipifera</i>	1.45				2.88		9.37	3.00
<i>Nyssa sylvatica</i>	1.56	.81		0.99	1.82			
<i>Pinus echinata</i>	1.45			4.46	26.20	0.73		
<i>Pinus virginiana</i>					34.50	92.84		
<i>Platanus occidentalis</i>							7.72	5.40
<i>Prunus serotina</i>		1.00			5.43			
<i>Quercus alba</i>	28.96	51.39	31.13	39.27	5.86		3.87	2.40
<i>Quercus bicolor</i>								3.39
<i>Quercus coccinea</i>			22.88					
<i>Quercus falcata</i>	1.45			21.94	1.82		1.11	
<i>Quercus lyrata</i>							1.92	
<i>Quercus marilandica</i>				3.47				
<i>Quercus palustris</i>								3.39
<i>Quercus phellos</i>								2.40
<i>Quercus prinus</i>		26.46	13.15					
<i>Quercus rubra</i>	6.35	2.62					6.91	
<i>Quercus stellata</i>	1.45	1.62	3.25	10.43	0.75			
<i>Quercus velutina</i>	19.81	1.62	10.46	2.50				
<i>Ulmus americana</i>							0.81	2.40
Total Dominance (m ² /ha)	30.00	31.00	26.58	33.98	44.68	35.00	20.32	33.33
Total Density (# trees > 4 in. DBH/ha)	407.43	397.89	313.73	350.13	498.67	1098.15	238.72	381.96

^a Stands 1 through 4 are upland hardwoods, 7 and 8 are bottomland hardwoods, and 5 and 6 are pine stands.

Upland Woods

The upland woods of the area can be divided into three major subdivisions on the basis of quantitative data: 1) deciduous woods 2) mixed pine-deciduous woods 3) pine woods.

Deciduous Woods

The deciduous woods of the study area have been classified as members of the oak-hickory forest in the Temperate Deciduous Forest Biome (Shelford 1963), and from the data obtained, most seem to fit this designation. The oak-hickory community type is represented by stands 1-4 (Table 2). It can be seen here that there is significant variation among the four stands sampled. *Quercus alba* is the leading dominant in all four stands, but in stand 1 the leading associate is *O. velutina*, in stand 4, *Q. falcata*, in stand 2, *Q. prinus*, and in stand 3, *Q. coccinea*, through *Q. prinus* plays an important structural role here also. The dominance of *Q. alba* in these stands agrees with the findings of Gemborys (1974) in another Piedmont Virginia locality, Prince Edward County, where *Q. alba* was found as the leading dominant more than any other species. Stands 2 and 3 are located on a rocky slope and dry uplands respectively, and these habitat differences could partially explain the greater structural importance of *Q. prinus* in these two stands. This is also in agreement with the findings of Gemborys (1974), who found *Q. prinus* to be most important in xeric upland or rocky sites. The soil of the deciduous woods represented by stand 1 has considerable amounts of calcium and magnesium (Table 1) and the importance of *Q. velutina* (I.V. = 19.82) in this rich, mesic woods seems to agree with the findings of Oosting (1942) in Piedmont (Durham County) North Carolina. Oosting found that *Q. alba*-*Q. velutina*-*Q. falcata* type forests occurred primarily on the better upland sites.

Common canopy associates in the deciduous woods sampled include *Carya glabra*, *C. ovata*, *C. tomentosa*, *Quercus rubra*, *Q. stellata*, *Q. marilandica*, *Liriodendron tulipifera*, *Liquidambar styraciflua*, *Nyssa sylvatica*, and *Fraxinus americana*. Understory species present include *Cornus florida*, *Carpinus caroliniana*, *Acer rubrum*, and *Chionanthus virginicus*.

The herb layer present varies greatly depending on a number of factors and provides an interesting aspect of community diversity. Stands 1 and 2 are most similar in terms of herbaceous cover, both having a much richer and more diverse herb layer than the other stands sampled. A possible explanation is that while the two stands differ a great deal in tree composition, both are located on slopes above streams. In terms of the herb layer supported, the very rocky substrate of stand 2 does not seem very different from stand 1 with its much deeper soil. Species found in both stands include *Stipa avenacea*, *Melica mutica*, *Oxalis stricta*, *Coreopsis auriculata*, and *Chrysogonum virginianum*. Other species found in one or the other of these stands include *Iris verna*, *Liparis lilifolia*, *Ranunculus hispi-*

us, *Silene stellata*, *Thaspium trifoliatum*, *Chimaphila umbellata*, *Pyrola rotundifolia*, and *Erigeron pulchellus*. The herb layer of stands 3 and 4, almost depauperate in comparison with stands 1 and 2, includes such species as *Cypripedium acaule* and *Chimaphila maculata*.

A particularly interesting floristic association is located in deciduous woods on and above the old Adam's millrace, beside Kent Branch about one-half mile from its confluence with Venable Creek. The site was not sampled quantitatively due to evidence of selective timbering operations in the past. The area is quite limited in size, stretching approximately 100 yards along the millrace and the slopes above. One unusual aspect of the site is an extremely extensive and dense colony of *Adiantum pedatum* with a large amount of *Lycopodium lucidulum* beneath. Other species of interest include *Chamaelirium luteum*, *Amianthum muscaetoxicum*, *Aconitum uncinatum*, *Gilenea trifoliata*, *Aruncus dioicus*, *Obolaria virginica*, and *Phlox carolina*. The last seven of these species have been observed nowhere else in the study area, and the sloped, northfacing, very mesic habitat apparently satisfies certain ecological requirements. The lack of other suitable habitat seems to severely limit their distribution in other parts of the Kent Branch Watershed.

Mixed Pine-Deciduous Woods

This community type is the result of secondary successional processes and can be formed in several ways, including abandonment of old fields and clearcutting. There is a large amount of variation in the mixed pine-deciduous woods ranging from areas where *Pinus virginiana* predominates, such as stand 5 (Table 2), to those where deciduous trees predominate. Canopy species often found in this community type include *Pinus virginiana*, *P. echinata*, *Quercus* spp., *Acer rubrum*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, and *Nyssa sylvatica*. Understory trees include *Carpinus caroliniana* and *Cornus florida*. Herbaceous and shrub components of the community vary with the amount of canopy cover and other factors, but often include such species as *Rhus radicans*, *Chimaphila maculata*, *Euonymus americanus*, *Lonicera japonica*, and *Lycopodium flabelliforme*.

Pine Woods

There are large areas of pine woods in the Kent Branch Watershed. These are the result of both pine plantation operations and natural successional processes. During the period since World War II, large lumber companies, as well as private land owners, have planted extensive areas of land in *Pinus taeda*. Some of these plantations are quite extensive, occupying as much as a thousand acres. There is also one small plantation of *Pinus strobus* in the study area. The remainder of the pine woods in the area are the result of secondary succession, the process usually beginning with the abandonment of cultivated fields. Typical

pine woods in the Kent Branch Watershed are dominated by *Pinus virginiana* and *P. echinata*. Common associates in the shrub and herb layers include *Cyrtopodium acaule*, *Andropogon scoparius*, and *Vaccinium* spp.

Stand 6 is an example of a rather unusual pine woods. The canopy of this stand is dominated by *Pinus virginiana*, with an occasional *P. echinata*. There is a low understory of scattered *Juniperus virginiana*, and a shrub layer dominated by saplings of *Quercus* spp. with *Nyssa sylvatica* as an associate. Within this stand there are open areas with few pines, but with lichens covering a high percentage of the ground. An unusual floral association occurs in and around the open areas. Species of interest include *Corallorhiza odororhiza*, *Muhlenbergia capillaris*, *Gymnopogon ambiguus*, *Sorghastrum nutans*, *Aristolochia serpentaria*, and *Liatris squarrosa*. This stand, located on rocky slopes above Kent Branch, seems to be second growth developing after cultivation, sheet erosion, and timbering. In certain respects, the area resembles pine barren habitats and explanations for this resemblance could include slope, rocky substrate, and progressive erosion.

Bottomland Woods

Bottomlands in the Kent Branch Watershed are mostly narrow floodplains along small streams. In many areas this habitat is under cultivation or in pasture. Other bottomlands, once used for agricultural purposes, have since been abandoned, resulting in the onset of secondary succession. This section deals with bottomlands which are wooded at the present time, stands 7 and 8 being examples. Stand 7 (Table 2) occupies a very wet area below an old millrace just off Kent Branch. There is some evidence of logging operations in the past, but quite some time has elapsed since the disturbance. *Acer rubrum* and *Carpinus caroliniana* are the dominants while other tree species of importance include *Liriodendron tulipifera*, *Betula nigra*, *Platanus occidentalis*, *Liquidambar styraciflua*, and *Quercus rubra*. The herbaceous layer includes *Glyceria striata*, *Carex* spp. and *Juncus* spp. There are differences in elevation of up to two feet in this stand, with tree species occupying the higher ground, and *Carex* spp. and other moisture tolerant species occupying the lower areas, which often have standing water.

Stand 8 (Table 2) is located in the floodplain of Kent Branch about one-half mile above its confluence with Venable Creek. This stand is frequently flooded and like the preceding one has slight differences in elevation. Here also, trees occupy the higher ground with herbaceous species such as *Carex* spp., *Juncus* spp., and *Cardamine bulbosa* occupying the lower areas, which are often filled with standing water. Tree species of importance here include *Carpinus caroliniana*, *Acer rubrum*, *Liquidambar styraciflua*, *Fraxinus pennsylvanica*, *Platanus occidentalis*, and *Quercus bicolor*. The structural importance of *Q. bicolor* is somewhat greater than that suggested by the data. Just outside the sampling area is a large grove of *Q. bicolor* and

both these and the individuals in the sampling area are the largest trees in this section of floodplain. The soil here differs significantly from that of all other stands studied. The site is in a poorly drained mixed alluvial area (Porter et al. 1958) and the high levels of potash and salt (Table 1) as well as other factors resulting from poor drainage, probably significantly influence the vegetation.

Freshwater Lakes and Marshes

Despite the fact that there are no natural bodies of standing water in the Kent Branch Watershed, there is a sizable amount of habitat present for aquatics, emergents and other plants that require or tolerate a great deal of moisture. In the past, such environments were provided by the numerous millponds that were situated on Kent Branch and its tributaries. This type of habitat is represented at the present by a large number of small man-made lakes and farm ponds, and also by a sizable number of beaver ponds.

Among the more interesting taxa found in wet habitats are *Erianthus giganteus*, *Xyris torta*, *Habenaria clavellata*, *Lysimachia nummularia*, and *Campanula aparinoides*.

Early Old Field Successional Areas

Although approximately 75 per cent of Fluvanna County is wooded (Porter et al. 1858), virtually none of the area is in mature forest. Most of the wooded portion is in various stages of secondary succession. Such areas have been treated in the sections on mixed pine-deciduous woods and pine woods. The present section deals with the successional sequence from the abandonment of cultivated fields to just after the closing of the canopy. There is a great deal of land undergoing such successional processes due to the increasing retirement of small farms as a result of economic pressures.

Early in the successional process, such taxa as *Andropogon virginicus*, *Seteria* spp., *Aster* spp., *Eupatorium* spp., and *Solidago* spp., predominate. As succession proceeds, such species as *Pinus virginiana*, *P. echinata*, and *Juniperus virginiana* become more and more important structurally. Upon closing of the canopy, the *Pinus* spp. and the *Juniperus virginiana* reduce light penetration to such an extent that the herb layer becomes almost nonexistent. Eventually, of course, shade-tolerant deciduous tree species will gain a foothold and ultimately come to dominance in most cases.

Recently Disturbed Areas

Included in this category are such habitats as roadsides, sawmills, and old homesites. A large number of species thrive under these conditions, a high percentage being of European nativity. Interesting species found in such habitats include *Artemisia ludoviciana* and *Eragrostis curvula*.

Distribution Records and Annotated Checklist of the Vascular Flora

A total of 752 species representing 402 genera of 111 families has been recorded from the Kent Branch Watershed. Of these, 733 are recorded for Fluvanna County, 87 are new to the Virginia Piedmont north of the James River, and 26 are Piedmont records. In the annotated checklist, those taxa that have previously been reported from Fluvanna Co., that is, are *not* county records, are preceded by an asterisk (*). Species not previously reported from the northern Piedmont are marked with a double asterisk (**), and Piedmont records are marked by a triple asterisk (***). Information on relative abundance in the study area is abbreviated as follows: A, abundant; LA, locally abundant; C, common; O, occasional; R, rare; SC, single colony or individual seen. Major habitat types have been abbreviated according to Table 3. Collecting numbers are those of the first author. The distributional information presented here was made available to Harvill, Stevens and Ware (1977) for inclusion in the Atlas of the Virginia Flora.

A complete set of voucher specimens has been deposited in the Herbarium of the College of William and Mary (WILL) and duplicate specimens have been deposited in the Herbarium of the University of North Carolina at Chapel Hill (NCU). Nomenclature used in the annotated checklist follows Radford, Ahles, and Bell (1968).

Plants of particular interest include *Coreopsis auriculata*, the Fluvanna record being the northernmost record on the East Coast (Smith 1976), *Campanula aparinoides*, which has been found only twice previously south of Maryland east of the Appalachian Mountains, and *Eragrostis curvula* whose only other

Table 3. Key to Habitat Abbreviations

1. Aquatic habitats
2. Abandoned homesites (plants persisting or rarely escaping)
3. Cultivated fields
4. Roadsides, weedy areas, waste places, and disturbed sites
5. Swampy areas
6. Low wet fields and marshy areas
7. Successional fields
8. Forest margins
9. Low wet woods
10. Rich mesic woods
11. Drier mixed deciduous woods
12. Rocky wooded slopes
13. Mixed pine-deciduous woods
14. Pine woods including cultivated pine plantations

Virginia station is Dinwiddie County.

During the course of this study, none of the classical Mountain-Coastal Plain disjuncts, including such taxa as *Helonias bullata*, *Magnolia tripetala*, and *Decodon verticillata* (Harvill 1965, 1972, 1973a), were found. In some cases, such an absence may be even more significant from a photogeographical viewpoint than the occurrence of the species. In this case, the absence of these taxa adds another piece of supporting evidence to the theory that these disjunctions are real, and not merely collecting artifacts due to a lack of knowledge concerning the Virginia Piedmont.

Annotated Checklist

PTERIDOPHYTES

- ASPIDACEAE: *Athyrium asplenoides*, 9, A; 506. ***Dryopteris cristata*, 9, SC; 443. *D. intermedia*, 9, SC; 375. *D. marginalis*, 12, O; 781. *D. spinulosa*, 9, SC; 450. *Onclea sensibilis*, 9, O; 788. *Polystichum acrostichoides*, 10, 11, 12, A; 767. *P. acrostichoides*, forma *incisum*, 14, SC; 1085. *Thelypteris hexagonoptera*, 10, O; 564. *T. noveboracensis*, 9, A; 465. *T. palustris*, 5, O; 907. *Woodsia obtusa*, 9, SC; 1075.

ASPLENACEAE: *Asplenium platyneuron*, 4, 12, 13, A; 5.

BLECHNACEAE: *Woodwardia areolata*, 9, O; 846, 961-1.

EQUISETACEAE: *Equisetum hyemale*, 9, O; 20, 1267.

LYCOPODIACEAE: *Lycopodium flabelliforme*, 9, 14, A; 1153.

L. lucidulum, 9, O; 1154. *L. obscurum*, 9, O; 1.

OPHIIOGLOSSACEAE: *Botrychium dissectum*, 11, C; 821, 638.

B. virginianum, 11, C; 196. *Ophioglossum vulgatum* var. *pycnostichum*, 9, O; 1346.

OSMUNDACEAE: *Osmunda cinnamomea*, 9, O; 479. *O. claytoniana*, 10, SC; 1590. *O. regalis*, 9, O; 599.

POLYPODIACEAE: *Polypodium virginianum*, 12, R; 49.

PTERIDACEAE: *Adiantum pedatum*, 10, LA; 445. *Dennstaedia punctilobula*, 10, O; 596. *Pteridium aquilinum*, 4, 8, 13, C; 837.

SELAGINELLACEAE: *Selaginella apoda*, 6, 9, C; 496.

CONIFEROPHYTES

CUPRESSACEAE: **Juniperus virginiana*, 4, 7, A; 1297.

PINACEAE: **Pinus echinata*, 13, 14, C; 1098. **P. strobus*, 14, O; 1300. ***P. taeda*, 14, A; 1299. **P. virginiana*, 7, 13, 14, A; 1286. **Tsuga canadensis*, 9, SC; 1253.

ANTROPHYTES

MONOCOTYLEDONAE

ALISMATACEAE: *Alisma subcordatum*, 5, 6, O; 610. *Sagittaria latifolia*, 1, SC; 1704-14.

AMARYLLIDACEAE: *Hypoxis hirsuta* var. *hirsuta*, 10, 11, 13, A; 110. *Narcissus pseudo-narcissus*, 2, 9, C; 1236.

ARACEAE: *Acorus calamus*, 5, SC; 343. *Arisaema dracontium*, 9, O; 541. *A. triphyllum*, 9, C; 117. *Symplocarpus foetidus*, 5, O; 377, 1191.

COMMELINACEAE: *Commelina communis*, 4, 9, C; 507, 483.

CYPERACEAE: *Bulbostylis capillaris*, 6, 0; 810, 869. *Carex*
anectens, 9, 0; 193. *C. blanda*, 11, 0; 162. **C. complanata*, 4, 9,
C; 221a, 264. **C. crinita* var. *crinita*, 5, 6, A; 242. *C. debilis*,
9, 0; 161. *C. festucae*, 9, C; 356. *C. flaccosperma*, 6, SC; 152.
C. frankii, 5, 6, C; 556, 1655. *C. grisea*, 9, SC; 1581. *C. howei*,
9, R; 269. *C. incompta*, 5, 6, 0; 154. **C. intumescens*, 9, C;
214, 266. *C. laevivaginata*, 5, 6, 0; 124. *C. laxiculmis*, 9, SC;
46. **C. lupulina*, 9, 0; 1108. **C. lurida*, 6, 9, A; 151, 456a.
C. pennsylvanica, 9, SC; 1293. *C. prasina*, 9, SC; 1385. *C. prolecta*,
9, 0; 290. *C. retroflexa*, 10, SC; 1394. *C. rosea*, 6, SC; 1406.
C. scoparia, 6, SC; 155, 0, 167a. *C. sparganioides*, 4, SC; 225.
**C. squarrosa*, 5, SC; 1704-7. *C. stricta*, 6, SC; 1422. *C. styloflexa*,
9, 0; 1339. *C. tribuloides*, 9, 0; 290. *C. vulpinoidea*, 4, 6, C;
224, 398. ****Cyperus esculentus*, 4, SC; 409. *C. flavescens*, 6,
0; 651. *C. ovalaris*, 4, 6, C; 1028, 1088. *C. strigosus*, 4, 6,
A; 494, 1024. **C. tenuifolius*, 4, 6, 0; 1051. *Eleocharis engelmannii*,
4, SC; 1141. *E. obtusa*, 6, C; 1089, 1125. ***E. quadrangulata*,
6, SC; 311. *E. tenuis*, 6, SC; 372. *Fimbristylis autumnalis*,
0; 811, 1134. ****E. dichotoma*, 4, SC; 970. *Rhynchospora*
capitellata, 6, A; 883, 1128. ****E. chalarocephala*, rocky portion
of small stream, SC; 1063. ****E. microcephala*, 9; 1149. *Scirpus*
atrovirens, 6, C; 153, 839. *S. cyperinus*, 5, 6, 9, C; 919, 1058.
S. polyphyllus, 5, 9, 0; 622, 1046. ***S. purshianus*, 6, C; 817, 1024.

OIOSCOREACEAE: *Oioscorea villosa*, 9, 0; 286.

IRIDACEAE: **Iris verna*, 10, SC; 1356. *Sisyrinchium angustifolium*, 4, 6, 10, 0; 1450-1. *S. micronatum* var. *micronatum*, 4,
10, 11, C; 109.

JUNCACEAE: *Juncus acuminatus*, 6, 0; 254, 1137. ****J. coriaceus*,
5, SC; 1086. *J. effusus*, 5, 6, C; 210, 1093. *J. marginatus*, 4, SC;
1135. *J. platyphyllus*, 6, 0; 867, 1073. *J. scirpoides*, 6, 0;
310, 1136. *J. tenuis*, 4, A; 322. ****Luzula bulbosa*, 9, 0; 168.
L. echinata, 5, 9, 0; 114, 249.

LILIACEAE: *Aletia farinosa*, 13, 0; 447, 1673. *Allium*
vineale, 3, 4, 7, A; 365. ***Amiantum muscatoxicum*, 9, SC;
1562. *Asparagus officinalis*, 4; 379. ***Chamaelirium luteum*,
10, SC; 1538. *Hamocallis fulva*, 2, 9, C; 364. *Medeola virginiana*,
12, SC; 1594. *Muscari racemosum*, 3, 4, C; 31. *Ornithogalum umbellatum*,
6, SC; 1383. *Polygonatum biflorum*, 9, 10, C; 200. *Smilacina racemosa*,
9, 10, C; 151. ***Smilax bona-nox*, 4, 9, 0; 963-1. *S. glauca*,
9, 10, 13, C; 1061, 1375. *S. herbacea*, 9, 10, 0; 1373. *S. hispida*,
9, 0; 1526. *S. rotundifolia*, 4, 9, A; 263. *Uvularia perfoliata*,
10, C; 823, 1317. *U. sessilifolia*, 10, SC; 1566. ****Yucca filamentosa*
var. *smalliana*, 4, C; 231.

ORCHIDACEAE: *Aplectrum hymale*, 10, SC; 1287. *Coralorrhiza*
odontorrhiza, 13, 0; 1071, 1082. *Cypripedium acaule*, 11, 13, 14,
0; 89. *Goodyera pubescens*, 9, 10, 0; 544. *Habenaria clavellata*,
5, 9, 0; 502, 573. *H. lacera*, 5, 9, 0; 509, 1669. *Liparis lilifolia*,
10, R; 502, 649. *Malaxis unifolia*, 13, SC; 1681.
Orchis spectabilis, 9, SC; 133. *Spiranthes cernua* var. *cernua*,
6, SC; 1119. *S. gracilis* var. *gracilis*, 11, 13, 0;
640, 688. ***S. grayi*, 13, 14, 0; 950, 1072. ***S. ovalis*, 9, 0;
832, 1053. ***S. vernalis*, 6, SC; 452. *Tipularia discolor*,
13, 0; 609.

POACEAE: *Agropyron repens*, 4, SC; 251, 326. *Agrostis hyemalis*,
4, SC; 1522. *A. perennans*, 10, 11, 12, A; 792. *A. stolonifera*,
3, 4, 7, A; 299, 434. ****Aira caryophylla*, 4, C; 1448. ****A. elegans*,
4, 0; 1646. *Andropogon scoparius*, 13, 14, 0; 1096. *A. virginicus*,
4, 7, A; 1026. *Anthoxanthum odoratum*, 4, 9, 0; 107, 284. *Aristida*
dichotoma, 4, A; 911. ***A. lanosa*, 7, SC; 1143. *A. longespica*,
4, SC; 973. *A. oligantha*, 4, C; 838. ***A. purpurascens*, 4, SC;
1056. ****Arrhaxon hispidus* var. *cryptatherus*, 6, 9, 0; 905.
Avena sativa, rarely escapes, 4; 1504. *Bromus commutatus*, 4, 0;
240. *B. isoponicus*, 4, C; 148. *B. purgans*, 9, C; 1034, 359.
P. polyanthes, 4, C; 429, 780. *P. scoparium*, 6, 7, C; 401a, 798.
P. stipitatum, 5, 6, C; 616. *Paspalum laeve*, 4, 6, A; 1007, 493.
****P. setaceum*, 6, SC; 880. *Phileum pratense*, 3, 4, A; 245.
Poa annua, 4, A; 35. *P. autumnalis*, 9, 0; 1489. *P. compressa*,
8, 9, 0; 319, 1673. *P. cuspidata*, 9, 0; 18. *P. pratensis*,
4, A; 121, 204. *Setaria faberii*, 3, 4, 1A; 946, 1022. ***S. geniculata*,
4, C; 662, 1043. *S. glauca*, 4, C; 937, 1131. *S. viridis*, 4, 0;
328. *Sorghastrum nutans*, 4, 14, 0; 1079, 1113. *Sorghum halepense*,
3, 1A; 329, 1087. *Sphenopholis nitida*, 9, 0; 1377. *S. obtusata*,
7, 8, 0; 1457, 1647. *Sporobolus clandestinus*, 4, SC; 973a. *Stipa*
avenacea, 12, R; 1319. *Tridens flavus* var. *flavus*, 4, 7, A; 771.
Tripsacum dactyloides, 4, 0; 402a, 991. *Trisetum pennsylvanicum*,
12, SC; 1419. *Trisetum aestivum*, an occasional escape, 4; 184.

***Uniola laur*, 9, 0; 797, 857. *Zea mays*, rarely escapes, 4; 565.
POTAMOGETONACEAE: ****Potamogeton opihydus*, 1, SC; 248.
SPARGANIACEAE: ****Sparganium americanum*, 5, 6, R; 399.
TYPHACEAE: *Typha latifolia*, 5, 6, 0; 418.
XYRIDACEAE: *Xyris torta*, 5, 6, R; 586.

OICOTYLEDONEAE

ACANTHACEAE: *Justicia americana*, on gravel or sand bars in

Kent Branch, 0; 283. *Ruellia carolinensis*, 10, 13, 0; 463.

ACEACEAE: *Acer negundo*, 9, 0; 1110. *A. rubrum*, 8, 9, A; 1298.

ALIZACEAE: *Mollugo verticillata*, 4, C; 386.

B. tectorum, 4, 0; 239. *Cinna arundinacea*, 9, A; 803, 1100.

Dactylis glomerata, 3, 4, A; 208. *Pantholia sericea*, 12, 0; 1511,

1649. *O. spicata*, 4, C; 256. *Oligitaria ischaemum* var. *ischaemum*,
4, 5, A; 806. *O. sanguinalis*, 4, 0; 661. *Echinochloa crusgalli*,
4, A; 981. *Elymus indica*, 4, C; 394, 436. *Elymus riparius*,
on sandbar in stream, SC; 958. *E. villosus*, 4, SC; 1130. *E. virginicus*,
4, 5, 8, 0; 433, 900. ***Eragrostis cilianensis*, 4, SC; 1683.

***E. curvula*, 4, SC; 1445. *E. spectabilis*, 4, 6, 0; 881, 945.

****Erianthus giganteus*, 6, SC; 1023. *Festuca elatior*, 3, 4, 7,

A; 149, 253. *F. myuros*, 4, 0; 298. *E. obtusa*, 9, 10, C; 360.

P. octoflora, 4, 6, C; 1520. *F. rubra*, 4, 14, 0; 313, 1460. *Glyceria*
striata, 5, 7, C; 317, 348. ***Cymopogon ambiguus*, 14, SC;
1070. *Holcus lanatus*, 4, 6, C; 211a, 361. ***Hordeum pusillum*,
4, 0; 252. *Hystrix patula*, 9, C; 277. *Leersia oryzoides*, 5, 6,
0; 783, 807a. *L. virginica*, 6, SC; 894. ***Lotium multiflorum*,
4, 0; 250. *L. perenne*, 4, SC; 1684. *Melica mutica*, 10, 12,
0; 287, 1320. ***Miscanthus sinensis*, 2, 0; 940, 976.

****Muhlenbergia capillaris*, 14, SC; 1151. *M. schreberi*, 4, A;
1021, 1054. ****M. sylvatica*, 9, SC; 1102. *Panicum anceps* var.

anceps, 4, A; 453. *P. boscii*, 13, O; 875. *P. capillare*, 4, C; 860. *P. clandestinum*, 6, 9, A; 903. *P. commutatum*, 6, O; 255, 613. *P. depauperatum*, 4, O; 1445-1. *P. dichotomiflorum*, 4, A; 949, 969-1. *P. dichotomum*, 4, A; 221. *P. lanuginosum*, 4, O; 430.

AMARANTHACEAE: *Amaranthus hybridus*, 4, A; 570, 571. *A. spinosus*, 4, A; 395.

ANACARDIACEAE: *Rhus copallina*, 4, 8, A; 1453-1. *R. glabra*, 7, 8, C; 412. *R. radicans*, 4, 8, 9, A; 602. *R. toxicodendron*, 13, Q; 870.

ANNONACEAE: *Asimina triloba*, 9, C; 1019.

APIACEAE: *Angelica venenosa*, 5, 6, O; 514. *Cicuta maculata*, 6, O; 704. *Cryptotaenia canadensis*, 9, O; 276, 753. *Daucus carota*, 4, 7, A; 458. *Hydrocotyle americana*, 9, O; 1677-1, 288. *Oxypolis rigidior*, 5, SC; 898. *Sanicula canadensis*, 9, O; 1682. ***S. smallii*, 9, 10, C; 199, 1515. *Thaspium barbinode*, 4, O; 170, 518. *T. trifoliatum* var. *trifoliatum*, 12, R; 1440-1. *Zizia aurea*, 10, SC; 1698.

APOCYNACEAE: *Apocynum cannabinum*, 4, C; 220, 615. *Vinca minor*, 2, C; 15.

AQUIFOLOGACEAE: *Ilex opaca*, 11, 13, A; 1248. *I. verticillata*, 9, O; 268.

ARALIACEAE: *Aralia racemosa*, 9, R; 925.

ARISTOLOCHACEAE: *Aristolochia serpentaria*, 10, C; 1044, 1464. *Hexastylis virginica*, 12, C; 53.

ASCLEPTADACEAE: *Asclepias incarnata* var. *pulchra*.

6, O; 513. *A. purpurascens*, 9, SC; 1101. *A. syriaca*, 4, C; 320. *A. tuberosa*, 4, O; 335. *A. viridifolia*, 4, O; 633. *Marelea carolinensis*, 9, SC; 1692.

ASTERACEAE: *Achillea millefolium*, 4, A; 607. *A. millefolium* forma *rosea*, 4, SC; 191. *Ambrosia artemisiifolia*, 4, A; 710. *A. trifida*, 6, SC; 1106. *Antennaria plantaginifolia* var. *arrogans*, 14, SC; 66. *A. plantaginifolia* var. *plantaginifolia*, 4, 8, A; 29. *Anthemis arvensis*, 4, O; 1435. *Arctium minus*, 4, O; 567. ****Artemisia ludoviciana*, 2, SC; 965. *Aster divaricatus*, 9, C; 901. ***A. dumosus*, 4, O; 724. *A. infirmus*, 12, O; 577. *A. patens*, 4, SC; 1105. *A. patens*, 4, 13, C; 259. *A. pilosus* var. *pilosus*, 4, 8, C; 1129. *A. punicus*, 5, O; 1068. *A. simplex*, 9, O; 1142. *A. undulatus*, 12, SC; 873. ****A. vimineus*, 4, 8, O; 1126. *Bidens aristosa*, 4, O; 1138. *B. bipinnata*, 4, A; 669. *B. frondosa*, 4, 5, C; 790, 834. ***B. polyneis*, 4, C; 947. *B. tripartita*, 5, 9, O; 899. *Cacalia atriplicifolia*, 4, 9, O; 527. **Carduus discolor*, 4, A; 852. *C. lanceolatus*, 4, A; 629. *C. pumilus*, 4, A; 467. *Centaurea muculosa*, 4, C; 336. *Chondrilla juncea*, 4, SC; 1476. *Chrysanthemum leucanthemum*, 4, C; 229. *Chrysogonum virginianum* var. *virginianum*, 10, C; 77, 226a. **Cichorium intybus*, 4, A; 238. ***Coreopsis auriculata*, 12, O; 1393, 1429. ***C. lanceolata*, 4, O; 140. *C. verticillata*, 4, 8, C; 232. *Eclicpta alba*, 4, O; 657. *Elephantopus carolinianus*, 9, 10, C; 642, 818. ***E. tomentosus*, 9, O; 733. *Erechtites hieracifolia*, 4, C; 708. *Erigeron annuus*, 4, A; 302. *E. canadensis* var. *canadensis*, 4, C; 566, 848. *E. canadensis* var. *pustillus*, 4, C; 647. *E. pulchellus*, 10, SC; 1366. *E. strigosus*, 4, A; 143. *Eupatorium album*, 13, O; 1069. *E. aromaticum*, 11, C; 789. *E. coelestinum*, 2, SC; 987. *E. fistulosum*, 5, 6, C; 706. *E. hyssopifolium*,

4, O; 758. *E. perfoliatum*, 6, C; 668. *E. rotundifolium* var. *ovatum*, 6, 9, C; 628. *E. rugosum*, 9, C; 759. *Galinsoga ciliata*, 4, SC; 1045. *Gnaphalium obtusifolium*, 4, C; 916. *G. purpureum* var. *purpureum*, 4, C; 179. *Helenium autumnale* var. *parviflorum*, 5, 9, O; 908, 923. *H. flexuosum*, 5, 6, O; 304, 339. ***Helianthus scrobatus*, 4, O; 876. *H. decapetalus*, 9, SC; 749. *H. divaricatus*, 4, O; 592-1. *H. strumosus*, 4, SC; 547. ***H. tuberosus*, 3, SC; 1067. *Helopsis helianthoides*, 4, C; 614, 627. *Heterotheca mariana*, 4, 8, 13, A; 637, 849. *Hieracium gronovii*, 12, SC; 681. ****H. pilosella*, 5, 6, O; 1473. *H. pratense*, 4, 8, 13, C; 166. *H. scabrum*, 4, SC; 770. *H. venosum*, 4, 13, A; 172. *Hypochaeris radicata*, 4, O; 417. *Krisia dandelion*, 9, O; 1349, 1412. *K. virginica*, 4, O; 56. *Lactuca canadensis*, 4, C; 461. *L. floridana*, 9, O; 1003. *L. scariola*, 4, C; 497. *Liatris squarrosa*, 4, 14, O; 1077. *Mikania scandens*, 4, C; 612. *Parchenium integrifolia*, 4, SC; 1535. *Prenanthes serpentina*, 4, 8, O; 957. **Pterhopappus carolinianus* var. *carolinianus*, 4, C; 190. *Rudbeckia fulgida*, 4, SC; 1012. *R. hirta*, 4, 7, A; 307. *R. laciniata*, 9, A; 591. *Senecio aureus*, 5, 9, C; 134. *S. anallii*, 4, C; 141. *Silphium trifoliatum*, 7, 8, O; 555. *Solidago altissima*, 4, C; 959. *S. bicolor*, 8, C; 887. *S. caesia*, 8, 9, C; 751. *S. erecta*, 4, 13, O; 951. *S. gigantea*, 4, 7, C; 619. *S. graminifolia*, 4, O; 975. *S. luncea*, 4, 7, C; 549, 796. *S. nemoralis*, 8, 13, C; 829, 888. ***S. odora*, 4, O; 933. ***S. puberula*, 4, C; 983, 1057. *S. rugosa* var. *rugosa*, 11, 13, C; 967, 979. *Senecio asper*, 4, SC; 321. *Taraxacum officinale*, 4, A; 341. ***Tragopogon dubius*, 4, R; 1413. ***T. porrifolius*, 4, O; 146. *Verbesina alternifolia*, 4, 6, C; 992. *Vernonia glauca*, 8, O; 598. *V. noveboracensis*, 6, C; 1033. *Xanthium strumarium* var. *glabratum*, 4, O; 968. *X. strumarium* var. *strumarium*, 4, SC; 869-1.

BALANITACEAE: *Imatiens capensis*, 5, 9, A; 510.

BERBERIDACEAE: **Podophyllum peltatum*, 9, C; 1321.

BETULACEAE: *Alnus serrulata*, 9, A; 744, 1194. *Betula nigra*, 9, C; 1384. *Carpinus caroliniana*, 9, A; 589. *Corylus americana*, 9, O; 283a.

BIGNONIACEAE: *Campsis radicans*, 4, O; 489, 380. *Catalpa speciosa*, 4, SC; 1663.

BORAGINACEAE: *Hackelia virginiana*, 9, 10, O; 687. *Lithospermum arvense*, 4, LA; 10. *Myosotis verna*, 4, 6, O; 1322.

BRASSICACEAE: *Arabis canadensis*, 12, SC; 1672. *Arabisopsis thaliana*, 4, C; 87. *Barbarea verna*, 4, C; 14. *B. vulgaris* var. *arctica*, 4, O; 32. ***Brassica napus*, 4, C; 9. *Capsella bursa-pastoris*, 4, C; 30. *Cardamine bulbosa*, 9, SC; 1270. *C. concatenata*, 9, SC; 1275. *C. hirsuta*, 4, A; 6. *C. pennsylvanica*, 5, 9, C; 73. *Draba verna*, 3, 4, C; 27. *Lepidium campestre*, 4, O; 88. *L. virginicum*, 4, C; 185. *Sisymbrium officinale* var. *leioleucum*, 4, O; 392. ***Thlaspi perfoliatum*, 4, SC; 33.

CALLITRICHACEAE: *Callitriche heterophylla*, 1, 5, O; 1291.

CAMPANULACEAE: *Campanula aparinoides*, 5, 6, R; 548. *Lobelia cardinalis*, 9, O; 505, 667. *L. inflata*, 4, 6, C; 485, 563. *L. puberula*, 6, 9, O; 716, 877. *L. spicata*, 8, 10, 13, O; 163, 400. *Specularia perfoliata*, 4, C; 195, 308.

CAPRIFOLIACEAE: *Lonicera japonica*, 2, 4, 9, A; 227. *Sambucus canadensis*, 6, 9, O; 241. *Symphoricarpos orbiculatus*, 2, 4, O; 481.

Viburnum acerifolium, 8, 13, 0; 167. *V. dentatum* var. *dentatum*, 9, 13, 0; 451. ***V. nudum*, 9, SC; 1666. *V. prunifolium*, 8, 9, 0; 74.

CARYOPHYLLACEAE: *Agrostemma githago*, 4, SC; 176. *Arenaria serpyllifolia*, 4, SC; 1481. *Cerastium glomeratum*, 4, 9, C; 1346. *C. holosteoides* var. *vulgare*, 4, 0; 1418. *Oianthus armeria*, 4, 0; 147. *Lychnis alba*, 4, SC; 500. *Saponaria officinalis*, 4, 6, 0; 459. *Silene stellata*, 12, SC; 576. *Stellaria graminea*, 6, 9, 0; 177. *S. media*, 4, A; 342. *S. pubera*, 9, 10, C; 51.

CELASTRACEAE: *Eucynus americanus*, 9, 11, 13, C; 171.

CHENOPODIACEAE: *Chenopodium album*, 4, A; 939. *C. ambrosioides*, 4, C; 861.

CISTACEAE: *Lechea racemulosa*, 4, 8, 0; 422, 840.

CONVOLVULACEAE: *Calystegia sepium*, 4, 0; 439. *C. spithamea*, 4, SC; 1472. ***Convolvulus arvensis*, 4, 0; 338. *Cuscuta campestris*, parasite growing on other plants, 4, 0; 366. *C. compacta*, parasite growing on other plants, 9, 0; 926. *Ipomoea hederacea*, 3, 4, C; 384a. *I. lacunosa*, 3, 4, C; 384b. *I. pandurata*, 3, 4, A; 382. *I. purpurea*, 3, 4, A; 468.

CORNACEAE: *Cornus amomum*, 5, 9, 0; 261, 435. *C. florida*, 10, 11, 13, A; 94.

CRASSULACEAE: *Penthorum sedoides*, 5, SC; 776. ****Sedum spectabile*, rarely escapes, 4; 969.

EBENACEAE: *Diospyros virginiana*, 4, 8, C; 295.

ERICACEAE: *Chimaphila maculata*, 11, 13, A; 330. *C. umbellata*, 13, 14, 0; 1074. *Gaylussacia baccata*, 11, A; 1438. *Kalmia latifolia*, 12, C; 228. *Lyonia ligustrina*, 8, 9, 0; 604, 284a. *Monotropa hypopitys*, 13, SC; 464. *M. uniflora*, 13, C; 198. ****Oxycodendrum arboreum*, 9, 10, 0; 1256. *Pyrola rotundifolia* var. *americana*, 9, 13; 822, 1579. *Rhododendron nudiflorum*, 9, 0; 79, 112. *Vaccinium atrococcum*, 11, 13, 14, A; 1449-1. *V. stamineum*, 4, 11, 13, A; 99. *V. vacillans*, 4, 11, 13, A; 1441-1.

EUPHORBACEAE: *Acalypha gracilens*, 4, 0; 1049. *A. rhomboidea*, 4, 0; 938. *Croton glandulosus* var. *septentrionalis*, 4, SC; 819. *Euphorbia corollata*, 4, 8, C; 199, 562. **E. cyarissias*, 2, SC; 1302. *E. maculata*, 4, C; 568. *Phyllanthus carolinensis*, 5, 6, 0; 702, 884.

FABACEAE: ***Albizia julibrissis*, 4, 0; 390. *Amphicarpa bracteata*, 13, 0; 737. *Apocis americana*, 5, 9, 0; 1561. *Baptisia tinctoria*, 4, 0; 271. *Cassia hebecarpa*, 6, 9, 0; 582, 1066. *C. fasciculata*, 4, 0; 624. *C. micranta*, 4, C; 559. *Cercis canadensis*, 8, 10, 13, 0; 62. *Crotalaria sagittalis*, 4, 0; 533. ***Desmodium marilandicum*, 13, C; 855. *D. nudiflorum*, 8, 13, C; 511. *D. paniculatum*, 8, 13, C; 644. *D. rotundifolium*, 10, 0; 1011. *D. viridiflorum*, 10, 0; 1148. *Galactia volubilis*, 8, 13, 0; 425, 548. *Gleditsia triacanthos*, 9, SC; 1080. *Lathyrus latifolius*, 2, 4, 0; 218. *Lespedeza capitata*, 4, 7, 0; 966-1. *L. cuneata*, 4, 0; 709, 835. *L. hirta*, 11, 0; 764. *L. intermedia*, 13, 0; 645. *L. procumbens*, 4, 0; 729, 932. *L. repens*, 4, 0; 316, 760. *L. stipulacea*, 4, C; 672. *L. striata*, 4, 0; 684. *L. virginica*, 4, 0; 726, 929. *Medicago lupulina*, 4, 0; 590. *M. sativa*, 4, 0; 460. *Meililotus alba*, 4, C; 217. *M. officinalis*, 4, C; 192. *Robinia pseudo-acacia*, 4, 8, C; 1548. *Strophostyles umbellata*, 4, 0; 522. *Stylosanthes biflora*, 4, 7, 0; 516.

Tephrosia virginiana, 4, 0; 216. *Trifolium agrarium*, 4, SC; 333. *T. arvense*, 4, 0; 186. *T. campestre*, 4, C; 203. *T. pratense*, 4, A; 305. *T. repens*, 4, A; 127. *Vicia angustifolia*, 4, A; 98. *V. caroliniana*, 8, 9, 0; 106, 1324. *V. dasycarpa*, 4, LA; 173. ****Wisteria frutescens*, 2, SC; 1436.

FAGACEAE: *Castanea dentata*, stump sprouts, 11, R; 1470. *C. pumila*, 9, 11, 0; 373. *Fagus grandifolia*, 10, C; 1380. *Quercus alba*, 10, 11, 12, 13, A; 741. *Q. bicolor*, 9, SC; 1145. *Q. coccinea*, 11, C; 1030, 1146. *Q. falcata*, 11, 13, A; 984, 1032. *Q. ilicifolia*, 8, 11, 0; 1640. *Q. marilandica*, 11, 13, C; 1442-1. *Q. palustris*, 9, 0; 1036, 1038. *Q. phellos*, 4, 9, 13, 0; 1084. *Q. prinus*, 11, 12, C; 1551. *Q. rubra* var. *rubra*, 11, 0; 742, 1144. *Q. stellata*, 11, A; 743, 762. *Q. velutina*, 11, C; 1642.

GENTIANACEAE: *Bartonia virginica*, 10, SC; 605. *Gentiana villosa*, 7, SC; 856. *Obolaria virginica*, 10, R; 1261, 1273. *Sabatia angularis*, 4, R; 611.

GERANIACEAE: *Geranium carolinianum*, 4, C; 119. *G. maculatum*, 10, 0; 1328.

HAMAMELIOACEAE: *Hamamelis virginiana*, 9, 0; 601. *Liquidambar styraciflua*, 9, C; 941.

HYPERICACEAE: *Hypericum gentianoides*, 4, 8, C; 847. *H. hypericoides*, 4, 0; 533. *H. mutilum*, 5, 6, C; 495. *H. perforatum*, 4, C; 332. *H. punctatum*, 4, C; 357.

JUGLANDACEAE: *Carya cordiformis*, 9, 0; 1037. *Carya glabra*, 11, C; 1147. *C. tomentosa*, 8, 11, C; 985, 1549. *Juglans nigra*, 2, 10, 13, 0; 1492.

LAMIACEAE: *Cunila origanoides*, 12, SC; 872. *Glecoma hederacea*, 2, 4, LA; 90. *Redeona pulegioides*, 4, SC; 676. *Lamium amplexicaule*, 4, C; 7. *L. purpureum*, 4, 0; 12. *Lycopus americanus*, 6, 9, 0; 585. *L. virginicus*, 5, 0; 980. ****Marrubium vulgare*, 4, SC; 100. *Mentha piperita*, 5, 0; 641. ***Monarda punctata*, 4, SC; 995. *Perilla frutescens*, 2, 0; 948. *Prunella vulgaris*, 4, C; 475. *Pycnanthemum incanum*, 4, 0; 626. *P. tenuifolium*, 6, 7, 0; 843. *Salvia lyrata*, 4, 9, 0; 137. ****Satureja calamintha* var. *nepeta*, 4, LA; 408. *S. vulgaris*, 6, SC; 355. *Scutellaria elliptica*, 10, 0; 331. *S. integrifolia*, 9, 13, C; 246. *S. lateriflora*, 4, 0; 707. *Trichostema dichotomum*, 5, 6, 0; 721.

LAURACEAE: *Lindera benzoin*, 9, C; 16. *Sassafras albidum*, 8, 13, C; 580.

LINACEAE: *Linum striatum*, 4, C; 534. *L. virginianum*, var. *medium*, 4, 0; 308. *L. virginianum* var. *virginianum*, 4, 0; 558.

LOGANIACEAE: ***Polypremum procumbens*, 4, 0; 564a, 863.

LYTHRACEAE: *Cuphea viscosissima*, 6, SC; 716. ***Totala ramosior*, 5, 6, 0; 825.

MAGNOLIACEAE: *Liriodendron tulipifera*, 9, C; 630.

MALVACEAE: *Malva neglecta*, 4, C; 174. *Sida spinosa*, 4, C; 572.

MELASTOMATACEAE: ***Rhexia mariana* var. *mariana*, 4, 6, C; 389. *R. virginica* var. *virginica*, 4, 6, C; 663.

MENTISPERMACEAE: *Menispermum canadense*, 9, R; 1531.

- MORACEAE: *Morus rubra*, 2, 8, 0; 833.
- NYMPHAEACEAE: *Nuphar luteum*, 1, SC; 1000.
- NYSSACEAE: *Nyssa sylvatica* var. *sylvatica*, 11, 13, C; 850.
- OLEACEAE: *Chionanthus virginicus*, 10, 0; 851, 1133. *Fraxinus americana*, 13, 0; 754. *F. pennsylvanica*, 9, 0; 1002. *Ligustrum sinense*, 4, R; 1484.
- ONACRACEAE: *Circaea lutetiana* ssp. *canadensis*, 9, 0; 279. *Caura biennis*, 4, SC; 917. *Ludwigia alternifolia*, 4, 5, 6, C; 456. ***L. decurrens*, 5, 6; R; 650. *L. palustris*, 5, 6, A; 353, 816. *Oenothera biennis*, 4, C; 664. *O. fruticosa*, 4, 0; 588. ***O. lacinata* var. *lacinata*, 4, 0; 219.
- OROBANCHACEAE: *Epifagus virginiana*, with *Fagus*, 10, 0; 1015.
- OXALIDACEAE: *Oxalis dillenii*, 4, 0; 1507. *O. florida*, 4, SC; 1654. *O. stricta*, 4, 12, A; 1480, 1653. *O. violacea*, 9, 0; 135.
- PAPAVERACEAE: *Sanguinaria canadensis*, 9, 10, 12, 0; 25.
- PASIFLORACEAE: ***Passiflora lutea*, 9, 13, 0; 462, 1118.
- PHYMACEAE: *Phryma leptostachya*, 9, 13, 0; 423.
- PHYTOLACCACEAE: *Phytolacca americana*, 4, A; 267.
- PLANTAGINACEAE: *Plantago aristata*, 4, LA; 296. *P. lanceolata*, 4, A; 188. *P. rugelii*, 4, A; 472. *P. virginica*, 4, 6, 0; 309, 1292.
- PLATANACEAE: *Platanus occidentalis*, 9, C; 519.
- POLEMONIACEAE: *Phlox carolina*, 9, SC; 1539. *P. paniculata*, 2, SC; 757. ***P. subulata*, 2, 4, 0; 1234.
- POLYALACEAE: ***Polyala curtisii*, 4, 0; 487-1. *P. sanguinea*, 4, 6, R; 369. *P. verticillata*, 4, SC; 487.
- POLYGONACEAE: *Polygonum arifolium*, 5, 6, 0; 1010. *P. aviculare*, 3, 4, 0; 470. *P. cespitosum* var. *longisetum*, 4, 6, 0; 807. *P. convolvulus*, 4, 0; 325. *P. hydropiperoides* var. *hydropiperoides*, 1, LA; 1674-1. ***P. lapathifolium*, 4, 0; 537. *P. pennsylvanicum*, 6, 0; 902a. *P. persicaria*, 4, C; 407. *P. punctatum*, 5, 0; 486, 731. *P. sagittatum*, 5, C; 730. *P. scandens* var. *scandens*, 4, SC; 1116. ***P. setaceum*, 9, SC; 623. *Rumex acetosella*, 4, A; 118. *R. crispus*, 4, C; 237. *R. obtusifolius*, 4, 0; 763, 1560. *Tovara virginiana*, 9, 0; 752.
- PORTULACACEAE: *Claytonia virginica*, 9, A; 17, 1316-1.
- PRIMULACEAE: *Anagallis arvensis*, 4, SC; 583. *Lysimachia ciliata*, 9, 13, 0; 236. *L. nummularia*, 5, 0; 994, 1532. *L. quadrifolia*, 4, 8, 0; 314.
- RANUNCULACEAE: *Aconitum uncinatum*, 10, SC; 1040. *Anemone virginiana*, 8, 13, 0; 401. *Cnicifuga racemosa*, 9, 0; 924. *Clematis ochroleuca*, 12, 0; 138. *C. virginiana*, 4, 9, 0; 705. ***Delphinium ajacis*, escaped from cultivation, SC; 235. *Hepatica americana*, 9, 10, 12, 0; 24. *Ranunculus abortivus*, 4, 9, C; 11, 54. *R. bulbosus*, 4, A; 84. *R. hispidus*, 10, SC; 1284. ***R. parviflorus*, 4, SC; 1330. *R. recurvatus*, 9, C; 92. *Thalictrum polygamum*, 9, R; 1704-15. ***T. revolutum*, 9, 0; 213. *T. thalictroides*, 10, 12, 0; 50. ***Xanthorhiza simplicissima*, 9, A; 22, 1016.
- RHIANACEAE: *Ceanothus americanus*, 4, 8, 11, 0; 315.
- ROSACEAE: *Agrimonia parviflora*, 4, 9, C; 682, 802. *A. pubescens*, 4, 9, 0; 593, 639. *Amelanchier arborea* var. *arborea*, 7, 8, C; 64. ***A. spicata*, 8, SC; 1631. *Aruncus dioicus*, 10, SC; 1567. *Crataegus uniflora*, 7, 12, 13, 0; 431, 1462. *Duchesnea indica*, 6, SC; 1571. *Praparia virginiana*, 4, A; 72. *Coum canadense*, 8, 9, 0; 1487. *C. virginianum*, 12, SC; 575. *Cillenia trifoliata*, 10, SC; 1521. *Malus pumila*, 2, C; 1241. *Physocarpus opulifolius*, 8, R; 265. *Potentilla canadensis*, 4, 9, 13, A; 55. *P. norvegica*, 4, SC; 411. *P. recta*, 4, C; 144. *P. simplex*, 4, 9, C; 132. *Prunus americana*, 4, SC; 1469, 1609. *P. angustifolia*, 2, C; 1243. *P. avium*, 2, 0; 1245, 1645. *P. persica*, 2, C; 63. *P. serotina* var. *serotina*, 8, 11, 13, C; 301. *Pyrus communis*, 2, 0; 1246, 1255. *Rosa carolina*, 4, 0; 233. *R. multiflora*, 4, SC; 1060. *R. palustris*, 5, SC; 1688. ***R. wichuraiana*, 4, 0; 234. *Rubus allegheniensis*, 7, 8, A; 128, 1371. *R. argutus*, 7, 8, A; 1416b. *R. flagellaris*, 4, C; 1448-1, 1471. *R. occidentalis*, 4, 0; 278. *Sorbus arbutifolia* var. *arbutifolia*, 7, 0; 536. *Spiraea prunifolia*, 2, C; 1232.
- RUBIACEAE: *Ceanothus occidentalis*, 5, 6, 0; 415. *Diodia ceras*, 4, C; 539. ***D. virginiana*, 5, 6, 0; 345, 732. *Galium aparine*, 4, A; 181. *G. circaezanum*, 9, C; 280. *G. obtusum* var. *filifolium*, 4, 6, 0; 1335. *G. obtusum* var. *obtusum*, 4, 9, 0; 197. *G. pilosum*, 4, C; 426. *G. tinctorium*, 5, 6, 0; 1627. *G. triflorum*, 9, 10, 0; 1688. *Houstonia caerulea*, 8, 11, 13, A; 59. *H. purpurea*, 8, 10, 0; 159. ***H. pusilla*, 6, SC; 1278. *Mitchella repens*, 9, 11, 13, A; 4.
- SALICACEAE: *Populus alba*, 2, 4, 0; 419. *P. deltoides*, 2, 0; 553. *P. grandidentata*, 8, 0; 543. *Salix nigra*, 9, 0; 1496. *S. sericea*, 9, 0; 1266, 1352.
- SANTALACEAE: *Comandra umbellata*, 4, 8, 0; 1442.
- SAURURACEAE: *Saururus cernuus*, 9, 0; 378.
- SAXIFRAGACEAE: *Chrysothamnium americanum*, 9, SC; 1251. *Heuchera americana*, 9, C; 226. *Hydrangea arborescens* ssp. *arborescens*, 12, R; 785. *Philadelphus coronarius*, 9, SC; 376. ***P. inodorus*, 2, R; 1620. *Saxifraga pennsylvanica*, edge of small stream in rocky woods, SC; 1433. *S. virginiana*, 12, 0; 19.
- SCROPHULARIACEAE: ***Agalinis obtusifolia*, 4, 0; 769. *A. purpurea*, 4, 7, 0; 974. *A. tenuifolia*, 4, 11, 13, 0; 858, 1139. *Aureolaria laevigata*, 11, 0; 853. *A. pedicularia*, 4, 0; 1788. *A. virginica*, 4, 11, 0; 508, 631. *Chelone glabra*, on gravel bar in Kent Branch, SC; 1112. *Crataegus neglecta*, 6, 0; 344. *Linaria canadensis*, 4, 0; 180. *Lindernia angustifolia*, 5, 0; 180. *L. dubia*, 5, 0; 736. *Mimulus ringens*, 5, 6, 0; 525. *Paulownia tomentosa*, 4, 0; 942. *Pedicularis canadensis*, 9, 0; 136. *Pentstemon americanus*, 5, 0; 1625. *P. laevigatus*, 5, 8, 10, 13, 0; 194, 1488. *Verbascum blattaria*, 4, C; 337. *V. chapsus*, 4, A; 457. *Veronica arvensis*, 4, A; 1252. *V. officinalis*, 4, 6, 0; 165. *V. peregrina*, 10, SC; 1613. *V. serpyllifolia*, 9, 0; 122.
- SIMARUBACEAE: *Ailanthus altissima*, 4, 0; 620.
- SOLANACEAE: *Datura stramonium*, 4, A; 405. *Physalis heterophylla*, 14, SC; 1076. ***P. virginiana* var. *virginiana*, 4, SC; 241a. *Solanum americanum*, 4, 0; 471, 670. *S. carolinense*, 3, 4, A; 189, 499. ***S. rostratum*, 4, SC; 658.
- STAPHYLACEAE: *Staphylea trifolia*, 9, SC; 1376.
- ULMACEAE: *Celtis occidentalis*, 9, 0; 1364. *Ulmus americana*, 9, 0; 1035. *U. rubra*, 9, 0; 542.

URTICACEAE: *Boehmeria cylindrica*, 4, 9, A; 490. *Pilea pumila*, 9, C; 1109.

VALERIANACEAE: *Valerianella radiata*, 4, 0; 1363.

VERBENACEAE: *Verbena simplex*, 3, 4, 0; 388. *V. urticifolia*, 4, 0; 406.

VIOLACEAE: *Viola cucullata*, 4, 9, A; 1344. *V. emarginata*, var. *emarginata*, 4, C; 101, 1310. *V. fimbriatula*, 4, 0; 1301.

V. palmata var. *palmata*, 10, LA; 1410. *V. palmata* var. *sororia*, 12, 0; 1396. *V. palmata* var. *triloba*, 10, SC; 1272. *V. pedata*, 4, 0; 78, 1315. ***V. primulifolia*, 6, 0; 125. *V. rafinesquii*, 4, A; 13. *V. sagittata*, 4, 13, 0; 93.

VITACEAE: *Parthenocissus quinquefolia*, 8, 9, A; 1370. *Vitis aestivalis*, 9, 13, 0; 202. *V. labrusca*, 4, 8, 0; 1633. *V. riparia*, 12, 13, 0; 1662, 1676-1. *V. vulpina*, 9, 0; 1440.

Literature Cited

- Allard, H. A., and E. C. Leonard. 1943. The vegetation and floristics of Bull Run Mountain, Virginia. *Castanea* 8:1-64.
- . 1944. Additions to the flora of Bull Run Mountain, Virginia. *Castanea* 9:130-134.
- . 1952. The vegetation and flora of Bull Run Mountain, Virginia. *Castanea* 17:145-157.
- . 1962. List of vascular plants of the northern Triassic area of Virginia. *Castanea* 27:1-56.
- Beers, T. W. and C. I. Miller. 1964. Point sampling: research, results, theory and applications. *Purdue Univ. Res. Bull.* 786, Lafayette, Indiana.
- Bradley, Ted R. 1972. Plant records for northern Virginia and State. *Castanea* 37:49-59.
- . 1973. Plant records for the northern Virginia fall belt counties. *Castanea* 38:175-182.
- Gemborys, Stanley R. 1974. The structure of hardwood forest ecosystems of Prince Edward County, Virginia. *Ecology* 55:614-621.
- Gilman, E. M. 1957. Grasses of the Tidewater-Piedmont region of northern Virginia and Maryland. *Castanea* 22:1-105.
- Grimshaw, Susan, and Ted R. Bradley. 1973. Vascular flora of Great Falls National Park, Fairfax County, Virginia. *Castanea* 29:229-261.
- Harvill, A. M. Jr. 1965. The mountain element in the flora of the peninsula of Virginia. *Rhodora* 67:394-398.
- . 1972. The historical significance of some disjunct distributional patterns in Virginia. *Castanea* 37:137-140.
- . 1973a. Phytogeography of the Virginias and the equilibrium concept of landscape. *Castanea* 38:266-268.
- . 1973b. Distribution of the carices in Virginia. *Jeffersonia* 7:7-12.
- Hathaway, W. T., and Gwynn W. Ramsey. 1973. The flora of Pittsylvania County, Virginia. *Castanea* 38:38-78.
- Johnson, M. F. 1970. Additions to the flora of Virginia. *Castanea* 35:144-149.
- . 1971a. The genus *Liatis* in Virginia. *Castanea* 36:137-147.
- . 1971b. The genera *Carpheophorus*, *Mikania* and *Kuhnia* (Eupatorieae-Asteraceae) in Virginia. *Virginia Journal of Science* 22:38-41.
- . 1972a. Records preliminary to a flora of Virginia. *Castanea* 37:235-240.
- . 1972b. Eupatorieae (Asteraceae) in Virginia: *Eupatoriadelphus*, *Ageratine*, *Fleischmannia* and *Conoclinium*. *Virginia Journal of Science* 23:48-55.
- . 1974a. Cynareae (Asteraceae) in Virginia: *Arctium*, *Centaurea*, *Cnicus*. *Castanea* 39:205-228.
- . 1974b. Eupatorieae (Asteraceae) in Virginia: *Eupatorium* L. *Castanea* 39:205-228.
- . 1974c. Cynareae (Asteraceae) in Virginia: *Cirsium*, *Carduus*, *Onopordum*. *Virginia Journal of Science* 25:152-160.
- Lewis, W. H. 1958. The roses of Virginia and West Virginia. *Castanea* 23:77-88.
- Massey, A. B. 1961. Virginia flora. *Virginia Agr. Exp. Sta. Bull.* 155, 258 p.
- Mazzeo, Peter M. 1972. The gymnosperms of Virginia: A contribution towards a proposed state flora. *Castanea* 37:179-195.
- Nessler, C. L. 1976. A systematic survey of the tribe Cichorieae in Virginia. *Castanea* 41:226-248.
- Oosting, H. J. 1942. An ecological analysis of the plant communities of Piedmont, North Carolina. *Am. Midl. Nat.* 28:1-126.
- Porter, H. C., et al. 1958. Soil survey of Fluvanna County, Virginia. U.S. Dept. of Agriculture and Virginia Agricultural Exp. Station. Series 1947, No. 5. 178 p.
- Radford, A. E. et al. 1968. Manual of the vascular flora of the Carolinas. The University of North Carolina Press, Chapel Hill. 1183 p.
- Ramsey, Gwynn W. 1967. Interesting Plants for the Virginia Piedmont. *Castanea* 32:72.
- , et al. 1969. Plant records for the Virginia Piedmont and state. *Castanea* 34:199-203.
- Roane, Martha K. 1975. Rhododendrons native to Virginia. *The Virginia Journal of Science* 26:6-12.
- Roe, Gerald F. 1977. The Helenieae (Asteraceae) in Virginia. *Castanea* 42(1):42-50.
- Shelford, V. E. 1963. The ecology of North America. University of Illinois Press, Urbana. 610 p.
- Smith, Edwin B. 1976. A biosystematic survey of *Coreopsis* in eastern United States and Canada. *Sida* 6:123-215.
- Smith, James W., et al. 1964. Geology and mineral resources of Fluvanna County, Virginia Division of Mineral Resources Bulletin 79.
- Thacker, Wayne, et al. 1968. Plants new for the Virginia Piedmont and state. *Castanea* 33:135-136.
- U.S. Geological Survey. 1970. SW 1/4 Columbia 15' Quadrangle, Columbia and Zion Crossroads 7 1/2' Quadrangles. Washington, D.C.

NOTES

NOTES

NOTES

VIRGINIA JOURNAL OF SCIENCE

**VOL. 32, NO. 2
SUMMER 1981**

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware
Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer
Box 637
Lancaster, Va. 22503

©Copyright, 1980 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P.O. 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia and additional entry at Harrisonburg, Virginia 22801. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1980: \$15.00 per year, U.S.A.; \$20.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$4.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send address changes to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper (8½ × 11 inches). Margins should be not less than 1¼ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and affiliation, and proposed running title, all appear-

ing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first and last page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. *Metamorphic Textures*. Pergamon Press, New York. 350 pp.

Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians, Part III. Vertebrates* (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 32

No. 2

Summer 1981

TABLE OF CONTENTS



ARTICLES

- Interaction of 2, 4-D and Dicamba with Chitin and Chitosan. *Margaret V. Kemp and J. P. Wighman, VPI & SU.* 34
- Analysis of Predictor Variables of Student Achievement in General Education in Two Regional Universities. *Lois D. Hurdle, Norfolk State University* 38
- Science In-Service Training and Elementary Teacher's Attitudes Toward Teaching Science. *Alvin M. Pettus, VPI & SU.* 40
- Post-Embryonic Instars of a New Species of *Mydopholeus* (Acari : Astigmata : Rosensteiniidae). *Norman J. Fashing, College of William and Mary.* 43
- The Species of *Rhododendron* Native to North America. *Martha K. Roane, VPI & SU, and Josephine DeN. Henry, Henry Foundation for Botanical Research.* 49

Interaction of 2,4-D and Dicamba with Chitin and Chitosan

Margaret V. Kemp² and J. P. Wightman

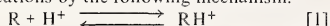
Department of Chemistry
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

Abstract—The interaction of the natural marine polymer chitin and its deacetylated derivative chitosan with the pesticides Dicamba and 2,4-D in aqueous solution has been investigated. The uptake of pesticides was determined from changes in concentration as measured by ultraviolet spectroscopy. A significant uptake of 2,4-D by chitosan and of the Dicamba by chitosan and chitin was observed. Chitosan was studied by both scanning electron microscopy (SEM), energy dispersion analysis of X-rays (EDAX) and electron spectroscopy for chemical analysis (ESCA) before and after equilibration with 2,4-D. The mechanism of uptake of 2,4-D by chitosan is absorption based on kinetic measurements and the EDAX spectrum for chlorine. The ESCA spectra provided further evidence for the uptake of 2,4-D on chitosan.

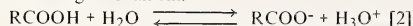
Introduction

Chitin or poly-N-acetyl-D-glucosamine is a natural polymer found in the exoskeleton of insects, crabs, and other crustaceans. Muzzarelli (1977) has written an excellent summary of different aspects of chitin including its preparation, characterization and properties. In light of the abundance of chitin in the marine environment, it is surprising that only a few articles have been published on the interaction of pesticides with chitin. Early work by Lord (1948) reported that DDT is sorbed by chitin.

Work reported by Muzzarelli (1977) has shown that a certain class of nonionic pesticides called benzoyl-phenylureas are capable of halting chitin synthesis. In addition to nonionic pesticides, Weber (1972) has noted three other types of pesticides, namely, cationic, basic, and acidic. The basic pesticides exist in aqueous solutions as cations by the following mechanism:



Acidic pesticides form anions in aqueous solution by the following mechanism:



The objective of this research was to determine what types of pesticides would be capable of removal by chitin and its deacetylated derivative, chitosan, and to determine the mechanism of removal.

Experimental

Materials—Processed chitin (VITIN) and chitosan were obtained from the Velsicol Chemical Corporation, Chicago. The pesticides tested were Atrazine, 2,4-D, Propanil, Paraquat, and Dicamba. Samples of Atrazine, 2,4-D, Paraquat, and Dicamba were obtained from the Department of Plant Pathology and Physiology at Virginia Tech. Propanil was obtained from the Environmental Protection Agency, Research Triangle Park, N.C. All pesticides used in testing were technical grade.

Techniques—Ultraviolet spectra of dilute aqueous solutions of the pesticides were obtained using an Hitachi 100-60 spectrophotometer. Photomicrographs of chitosan were obtained using an Advanced Metals Research 900 scanning electron microscope (SEM). Qualitative analysis of chitosan was obtained using an energy dispersive analysis of x-rays (EDAX) attachment on the microscope. Electron spectroscopy for chemical analysis (ESCA) spectra of chitosan were obtained using a duPont 650 electron spectrometer with a Mg x-ray source.

Procedures—A stock solution of each pesticide was prepared in the following concentrations (c):

Pesticide	C (moles/l)	λ max(nm)
Atrazine	$4.63 \times 10^{-5} M$	225
2,4-D	$2.27 \times 10^{-3} M$	285
Paraquat	$5.83 \times 10^{-4} M$	262
Propanil	$2.75 \times 10^{-4} M$	248
Dicamba	$1.15 \times 10^{-3} M$	280

Each stock solution was then diluted with distilled water to make five 200 ml solutions with concentrations down to 20% of the stock solution. Each 200 ml solution was then divided into 50-ml portions. To two 50 ml solutions, 0.1 g of chitosan or chitin was added. A third 50 ml solution was used to make a calibration plot of absorbance (at a characteristic wavelength) vs. concentration. The wavelengths (λ) used for each compound are noted above.

Each flask was shaken manually once each hour for two hours after the sorbent was added. All of the flasks were then allowed to equilibrate for approximately 15-20 hrs. A small aliquot of the equilibrated solution was pipetted from the center of the flask and placed in the UV sample cell. Distilled water was used as a reference. The UV spectra of the calibration and equilibrated solutions of a particular pesticide were obtained within a 2-hour period.

Final concentrations of the solutions containing the sorbent were determined by interpolation from the calibration plot. The change in concentration was determined for each solution and a plot of $\Delta C/W$ vs. equilibrium concentration, C_f , was made to construct

Footnotes

¹This research was done under the 1979 NSF-Undergraduate Research Participation Program at Virginia Tech. Dr. J. W. Viers, Director.

²Department of Chemistry, Bethany College, Bethany, W. Va.

the sorption isotherm. Here V is the volume of solution (50 ml in each case), ΔC is the change in pesticide concentration on equilibration with W grams of the sorbent.

Chitosan samples after equilibration with a $2.27 \times 10^{-3} M$ (initial) solution of 2,4-D were filtered and air dried at $100^\circ C$ for about 30 minutes. Some of the dried flakes were then placed on copper conductive tape for SEM analysis and on double stick tape for ESCA analysis. The C1s photopeak was used as a reference at 284.6 eV.

A kinetic study of 2,4-D on chitosan was also performed. A series of 11-50 ml flasks containing a $2.27 \times 10^{-3} M$ solution of 2,4-D were prepared. 0.1g chitosan was added to each of the flasks at a time $t=0$. The UV spectra of flask Nos. 1 and 2 were taken 30 and 60 minutes, respectively, after addition of the chitosan. This process was repeated over the next $4\frac{1}{2}$ hours for flask Nos. 3-11.

Results and Discussion

Sorption isotherms—A significant uptake of 2,4-D on chitosan was noted as shown in Figure 1. The shape of the isotherm is somewhat peculiar, although Giles (1969) and Bowman (1973) have reported similar behavior albeit in different systems. The initial convexity is suggestive of minimal interaction analogous to the adsorption of gases on solids as determined by Brunauer (1945). The linear increase at higher concentration is suggestive of a solution process as was observed by Dole (1972) for nitrophenol uptake from

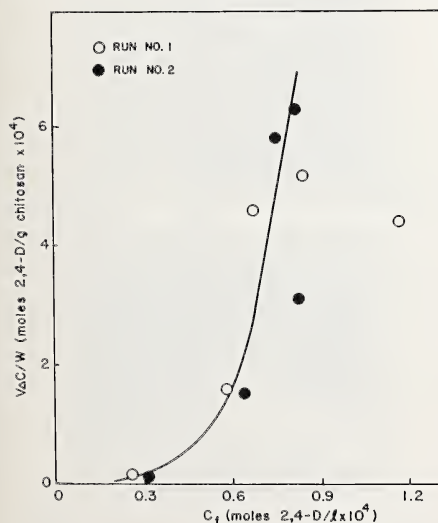


FIG. 1 Isotherm for the uptake of 2,4-D on chitosan.

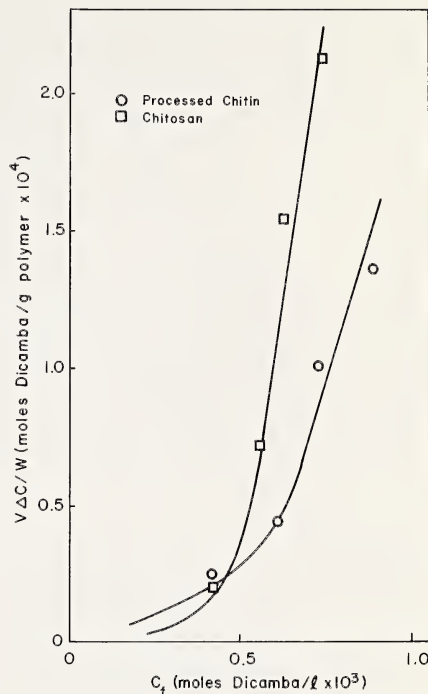


FIG. 2 Isotherms for the uptake of Dicamba on chitosan and processed chitin.

aqueous solution on Nylon. In short, the shape of the isotherm does not permit ready interpretation in terms of an adsorption process. Hence the term sorption is used to describe the uptake of 2,4-D by chitosan. There was no significant uptake of 2,4-D by chitin.

A significant uptake of Dicamba on both chitosan and chitin was noted as shown in Figure 2. The shape of the isotherms is quite similar to that observed for 2,4-D on chitosan (cf Fig. 1). The greater slope for Dicamba on chitosan compared to chitin may suggest a higher sorption of Dicamba on chitosan.

The kinetic results for the uptake of 2,4-D on chitosan are shown in Figure 3. The linear dependence of the quantity of 2,4-D taken up by chitosan as a function of the square root of time suggests a physical process in which the rate is controlled by the diffusion of 2,4-D into chitosan. A pseudo diffusion constant (D) can be calculated from the equation

$$D = (S/C_1)^2 \quad [3]$$

where S is the slope in Figure 3 for an initial 2,4-concentration of C_1 . The average calculated D value is $0.134 \pm 0.003 \text{ l}^2 \text{ g}^{-1} \text{ min}^{-1}$. The linearity of the

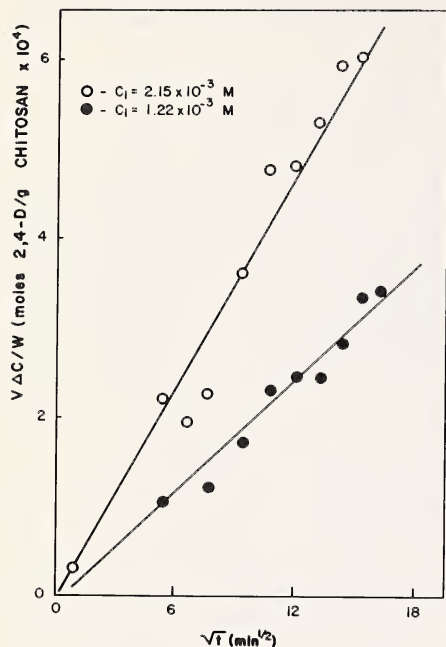


FIG. 3 Kinetics of the uptake of 2,4-D by chitosan.

data in Figure 3 and the constancy of the value of D supports an uptake mechanism involving the absorption of 2,4-D by chitosan. It is suggested that Dicamba is also absorbed by both chitin and chitosan.

There was no significant uptake of Atrazine, Paraquat or Propanil on either chitin or chitosan. The finding that only the acidic pesticides which form anions in water are taken up suggests that the uptake may be related to the formation of anions. Muzzarelli (1977) has shown that many acids are sorbed onto chitin through salt formation or hydrogen bonding. The probable bonding site is believed to be the amino group due to protection of the hydroxy and ether groups on the glucosidic rings by solvation with water.

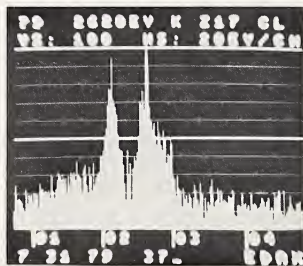
Scanning electron microscopy/energy dispersive analysis of x-rays (SEM/EDAX)—SEM photomicrographs of chitosan after equilibration with 2,4-D are shown in Figure 4. The EDAX spectrum for C1 in an equilibrated chitosan sample is also shown. No distinctive differences in surface features of chitosan before and after equilibration with 2,4-D was noted. Thus, the uptake of 2,4-D by chitosan does not result in changes in the surface morphology of chitosan. On the other hand, a significant chlorine EDAX signal is obtained



(A)



(B)



(C)

FIG. 4 SEM photomicrographs at 50X (A) and at 500X (B) of chitosan equilibrated with 2,4-D showing Cl in the EDAX spectrum (C).

for chitosan after equilibration with 2,4-D. Kang (1978) has shown that powdered silica with strongly adsorbed HCl on the surface gives no significant Cl EDAX signal. The difference in these two sets of results again supports an absorption mechanism for the uptake of 2,4-D by chitosan.

Electron spectroscopy for chemical analysis (ESCA)—The C 1s, O 1s, N 1s, and Cl 2p photopeaks obtained for chitosan equilibrated with 2,4-D are shown in Figure 5. The binding energies (B.E.) and atomic fractions (A.F.) for the major photopeaks of chitosan and equilibrated chitosan are given in Table I. The significant result here is that Cl is observed in equilibrated chitosan but not in unequilibrated chitosan. This result again demonstrates the uptake of 2,4-D on chitosan.

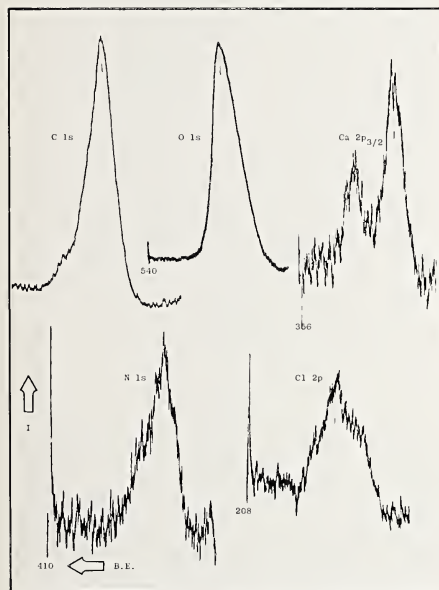


FIG. 5—Major ESCA photopeaks of chitosan after equilibration with 2,4-D.

TABLE I
ESCA Parameters for Chitosan and Chitosan/2,4-D

Element	CHITOSAN		CHITOSAN/2,4-D	
	B.E. (ev)	A.F.	B.E. (ev)	A.F.
N 1s	399.6	0.04	399.6	0.03
Cl 2p	-	-	200.2	0.01
O 1s	532.2	0.20	532.4	0.23
C 1s	(284.6)	0.76	(284.6)	0.71
Ca 2p _{3/2}	346.8	< 0.01	347.3	0.02

Acknowledgements

The authors wish to thank the National Science Foundation for financial support of this program and in particular a summer stipend for one of us (M.V.K.). Our efforts in this research program were aided greatly by a number of persons at Virginia Tech including Harold Bell, Wayne Bingham, John Dillard, Paul Field, Yoonok Kang, Frank Mitsianis, Ranjani Sirwardane and Rodney Young. The continuing interest of Peter Perceval in this research is appreciated.

References

- Bowman, B. T. (1973): Effect of saturating cations on the adsorption of Dasanit, o,d-diethyl o-[p-(methylsulfinyl)phenyl] phosphorothioate, by montmorillonite suspensions. *Soil Sci. Soc. Amer., Proc.*, 37, 200-7.
- Brunauer, S. (1945): *The Adsorption of Gases and Vapors*, pp. 7-28, Princeton Univ. Press, Princeton, N.J.
- Dole, L. R. (1972): Adsorption of Aromatic Solutes from Aqueous Solutions onto Hydrophobic Surfaces. Ph.D. Dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA.
- Giles, C. H., MacEwan, T. H., Nakhwa, S. N. and Smith, D. (1960): Studies in adsorption. Part XI. A system of classification of solution adsorption isotherms and its use in diagnosis of adsorption mechanisms and in measurement of specific surface areas of solids. *J. Chem. Soc.* 3973-93.
- Kang, Y. (1978): Adsorption of Hydrogen Chloride on Microcrystalline Silica. M. S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA.
- Lord, K. A. (1948): Sorption of DDT and its analogs by chitin. *Biochem. J.*, 43, 72-78.
- Muzzarelli, R. A. A. (1977): *Chitin*, Pergamon Press, Oxford.
- Weber, J. D. (1972): Interaction of organic pesticides with particulate matter in aquatic and soil systems. In *Adv. Chem. Series No. 111* (R. F. Gould, Ed.), pp 55-120, Am. Chem. Soc., Washington.

Analysis of Predictor Variables of Student Achievement in General Education in Two Regional State Universities

Lois S. Hurdle, Ph.D.

Psychology Department
Norfolk State University
Norfolk, Virginia 23504

Abstract—The purpose of this study was to explore relationships between selected demographic and cognitive variables and general education achievement and to identify variables that would predict achievement in general education programs in regional state universities.

This study involved undergraduates and graduates from two regional state universities. The first sample consisted of five hundred and thirty-five subjects from a Mid-Atlantic regional state university. The graduating classes from 1975 through 1979 comprised the population for the sampling. A random selection process was used to select the subjects, 100 from each class who took the general education section of the National Teacher Examination. Scores obtained by this sample of the population on the general education section of the NTE were examined in relation to cognitive and demographic predictor variables.

The second sample consisted of 79 undergraduate students from a South-Atlantic regional state university, who were administered the College Outcome Measures Project (COMP) Test. The COMP stresses generic outcomes necessary for effective adult roles in contrast to the NTE which stresses content mastery in disciplines. Scores obtained on the COMP were examined in relation to the same list of cognitive and demographic predictor variables used for the first sample.

The study design was basically longitudinal *ex post facto*. The principal statistical application was a step-wise multiple regression analyses. Eight hypotheses were developed to test the propositions of the study.

When first teaching psychology courses in a general education program, I was struck by the great variation among the students' achievement in their courses. Some students absorbed a great deal of the material, and others seemed more interested in courses in the department of their major. Females seemed more interested and appeared to have learned more than males; out-of-state students seemed to have learned more about college, generally, than did Virginia students.

I wondered if these variations would show up in the traditional exit tests from college such as the general education section of the National Teacher Examination (NTE), the Professional and Career Examination (PACE, a Civil Service Examination), and among scores from other outcome measures for college such as the Cooperative Test of General Culture.

When I began to read in this area, I was amazed by the general lack of studies in the area. While we have many studies predicting success in all college courses as defined by grades, we have few that look at test scores as outcomes. Also, there are few which look at general education and none that I could find that look at prediction in general education alone. The purpose of this study was to identify variables that will predict

achievement in general education by exploring relationships between selected variables and general education achievement.

Regional state universities were chosen for the study because of the uniformity of the programs of general education in such universities. Harclerod (1973) discusses this issue in his book entitled *Regional State College and Universities Entering the 1970's*. Since little or no research existed, I decided an analysis of predictor variables of student achievement in general education in regional state universities would be timely. Most general education programs in regional state universities are about 35 years old and most have been developed along the lines of the Harvard Report of 1945: *General Education in a Free Society*. Regional state universities also educate about a fourth of the students in American colleges, as they serve a region or quadrant of the state and are, therefore, near their clientele. Some examples are Western Michigan, Central Michigan, and Northern Michigan Universities. The schools in my study were labeled the Mid-Atlantic and South-Atlantic samples. These labels coincide with the Educational Testing Service and American College Testing Service labels for test score and analysis.

Method

A sample was generated that consisted of graduates of a regional state university who had completed the general education section of the National Teacher's Examination (NTE/GES) over a five year period. This first sample of NTE scores was labeled the South-Atlantic sample and consisted of 535 graduates. A second sample was labeled the South-Atlantic sample and consisted of 79 students who completed the new American College Testing Program's Outcome Measures Project Test (ACT/COMP). The students in this sample were younger and had completed at least 75% of a 48 credit general education program.

The general education programs of both sampled institutions stressed broad learnings in three areas: humanities, social sciences, and natural sciences. The tests stressed the same areas, but the ACT/COMP was designed to test the applications of these learnings in adult life while the NTE/GES was designed to test knowledge alone. The areas tested are English expression, social studies, arts and literature, mathematics, science, and verbal reasoning.

For each of the subjects in the sample, I gathered demographic and cognitive data designed to fit into

multiple regression equations as potential predictor variables. These data consisted of age, sex, socioeconomic status (SES), high school rank (HSR), high school quality point average (HSQPA), college quality point average (CQPA), state/non-state residence, dormitory/non-dormitory status, major, and standardized test scores: Scholastic Aptitude Test (SAT), American College Test (ACT), Graduate Record Examination (GRE), and School College Aptitude Test (SCAT). Their variables represented the independent predictor variables for the study while the NTE/GES and the ACT/COMP served as the dependent or outcome variables.

This research was a longitudinal ex post facto design as outlined in Kerlinger (1973). It involved samples of students, their records of achievement, and their personal attributes. These data are programmed into a stepwise multiple regression equation. Two tests of significance were applied: an F test for R^2 which indicates the significance of the variance accounted for and an F test for b in which the relative strength and significance of the individual variables is presented.

The step-wise multiple regression analysis technique was selected because it is a standard procedure for addressing the underlying problem of the study. A number of important products are provided by the multiple regression analysis. The amount of variance is measured by the square of the multiple correlation between achievement and the predictor variables. The second product is the equation. This equation takes the following form:

$$y + k + b_1x_1 \dots b_nx_n$$

where

y = the predicted criterion

k = a constant

b_1, n = a particular predictor variable

One limitation of the multiple regression equation is that there is no way of determining the precise contribution of the predictor variables because of the units involved. This confounds the order of contributions to the predictions; therefore, standardized regression weights were examined. The final product of this statistical technique was a multiple correlation between all significant predictors and the outcome variables (the NTE general education section and the COMP examination).

Results

A chart summarizing major results is presented herein. Demographic data such as age, sex, and socioeconomic status failed to explain a significant amount of variance in a stepwise multiple regression equation on either the NTE/GES or on the COMP test. There is no significant relationship between high school rank in class, college quality point average and scores on the GES or the COMP test. Academic major failed to explain a significant amount of variance on either the GES or COMP. Dormitory versus commuter status failed to explain a significant amount of variance on either test. Finally, there was no relationship between regional or non-regional residence on either test.

Outcome Variables	% of Variance Explained	Top Predictors
CES of NTE (when the data were disaggregated according to major for Liberal Arts majors (the liberal arts majors were certifying to teach in secondary schools)	39%	SAT, SCAT, GRE
Elementary Education Majors	34%	SAT, CQPA, GRE
Business Majors	47%	SAT, GRE
CES of NTE Segregated by Sex		
Females	44%	SAT, CQPA, SCAT, GRE
Males	43%	SAT, SCAT, GRE
COMP	19%	CQPA, SAT/ACT
COMP hierarchical regression equation	17%	CQPA, HSR

On the other hand, the SAT, ACT, SCAT, and GRE explained a significant amount of the variance (15-47%) in a stepwise multiple regression analysis on the NTE/GES and COMP. The standardized test (SAT, ACT, SCAT, and GRE) scores reached a level of significance, along with CQPA and HSQPA on both the NTE/GES and COMP. CQPA and HSQPA, along with socioeconomic status, reached a level of significance when data were separated according to sex and major. Most of the variance was explained by these variables on both the NTE/GES and the COMP Test.

Recommendations

The writer strongly recommends that replications of the present study be done in other regional state universities in other sections of the country and that the replications utilize the Comprehensive College Outcome Measure Project (COMP) test in regional state universities. The writer also recommends that research studies be undertaken that utilize a combination of HERL-KIT (a self-analysis kit) and the comprehensive COMP test as data gathering instruments. Finally, the writer suggests that longitudinal followup in ascertaining behavioral changes and "value added" attributable to general education. Withey, et al. (1971) have documented these phenomena for the college experience in *A Degree and What Else*. Separating out general education contributions has not been done and should be of great interest and value.

References

- Harclerod, F. (1973) *The Regional State Colleges and Universities Entering the 1970s*. Iowa City: American College Testing Program.
- Harvard Committee on General Education (1945). *General Education In A Free Society*. Cambridge, Massachusetts: Harvard University Press.
- Kerlinger, F. N. (1973) *Foundations of Behavioral Research* (Second Ed.). New York: Holt, Rinehart & Winston.
- Withey, S. B. (1971). *A Degree and What Else*. New York: McGraw Hill.

Science In-Service Training and Elementary Teacher's Attitudes Toward Teaching Science¹

Alvin M. Pettus, Assistant Professor

Division of Curriculum and Instruction
College of Education

Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

Abstract—An attempt was made to determine if a two-week period of intensive instruction in science content and two follow-up in-service sessions during an academic year can be effective for changing elementary school teachers' attitudes toward teaching science. Results were inconclusive but indicated that content training may indirectly facilitate changes in elementary teachers' attitudes toward teaching science when the teachers use the content knowledge in providing science instruction for their students.

Introduction

There appears to be increasing concern among science educators that science instruction is not being given adequate emphasis at the elementary school levels. Among the findings of DeRose, Lockard, and Paldy (1979:37) in their search of reports on National Science Foundation (NSF) studies was that less than half of the elementary school children in the U.S. are likely to experience a single school year in which they receive a significant amount of effective science instruction. The reports also indicated that science is given lower priority than other academic areas in the elementary school curriculum. Ankney and Rogers (1976:10) related that among the reasons elementary school teachers give for not teaching science are they do not like science and they do not know enough about it to feel comfortable and confident about teaching it.

One strategy for addressing the problems of lack of quantity and quality in science instruction for elementary school children is to provide elementary school teachers with enough of the right type of in-service training to help them feel better about teaching science or to help them develop better attitudes toward teaching science. The assumption is that improvements in teachers' attitudes will facilitate their teaching more science and doing a better job of teaching it.

A study of Spooner and Simpson (1979) indicated that even a five-day workshop involving teachers in "hands-on" experiences with science materials may improve the teachers' attitudes toward teaching science. Studies by Moore (1975) and Gabel and Rubba (1979) revealed that participation in short-term (several weeks) workshops on new science curricula is effective for changing elementary teachers' attitudes toward science and science teaching but the changes do not persist over time.

Problem

The purpose of this study was to determine if a two-week period of intensive (6 hours per day) instruction in science content and two brief follow-up in-service sessions over the period of an academic year would be effective for changing elementary school teachers' attitudes toward teaching science. An attempt was also made to assess changes in the teachers' science knowledge. Though Shrigley (1974) did not find a relationship between pre-service elementary school teachers' knowledge of science content and their attitudes toward science and teaching science, it is conceivable that increased knowledge of science content will cause in-service teachers to be more confident about teaching science or to have more positive attitudes toward teaching science.

Method

The subjects for this study were 17 elementary school teachers who were participants in a NSF sponsored program designed to improve the teachers' abilities to teach science through increasing their knowledge and understandings of science content and processes. The program included a concentrated two-week period of science learning experiences during the summer when university professors in several science content areas and in science education guided the teachers through activities or made presentations. Two Saturday follow-up sessions, one in November and one in late March of the same academic year, also included content training and some sharing of experiences among the teachers about using the content in their classrooms. No specific commercial science program was followed in the in-service sessions but effort was made to cover the life and physical science topics commonly found in the commercially available elementary science programs. Such topics as Matter and Energy, Motion, Organisms, and Ecosystems were included and the methods of instruction varied accord-

Footnote

¹This material is based upon work supported by the National Science Foundation under Grant No. SPI-7902168.

ing to topics and instructors. The participating teachers were also able to request assistance from the university professors for information and consultant services during the academic year. Many of them took advantage of the available assistance.

The teachers were asked to respond to items on an attitude measure and a science content measure at three different times—prior to receiving any instruction, after the two-week summer instructional session, and then near the end of the academic year.

The attitude instrument used was The Survey of Opinions Toward Elementary School Science Scale developed by Spooner and Simpson (1979). The instrument contains 20 items requiring responses to a Likert-type five-point scale ranging from strongly agree to strongly disagree. This instrument was chosen because the items related to opinions about teaching elementary school science which were not directly related to the content covered in the in-service sessions. Also, the writer thought this instrument would facilitate comparisons between the scale developers' findings based on a very short period of in-service involvement and findings based on a longer period of in-service. Spooner and Simpson reported the internal consistency of the instrument as .69 and .72 for 97 elementary teachers' pretest and posttest scores in their sample using Cronbach's Alpha.

The Sequential Tests of Educational Progress (STEP) Science Test; Series II, Form 2A was used as the content measure because it was thought to be on an appropriate level based on the teachers' previous science content training and it assesses knowledge of several areas of science content thought to be related to some of the content covered in elementary science programs. However, the content covered in the in-service sessions was not identified based on the test. A comparison study done subsequent to the last in-service session indicated the content addressed in most items of the test had not been covered in any direct manner in the sessions. The portion of the content test used contained 45 items.

Results

Means and standard deviations were calculated for the teachers' total scores on the content measure and the attitude measure at each administration of the measures. These data are presented in Table 1. Results of correlated t-tests to compare the scores obtained at each administration of the tests are shown in Table 2.

TABLE 1

Means and Standard Deviations for Total Scores on Content and Attitude Measures

Test	Pretest		Post Two-week Period		Post Academic Year	
	Mean	SD	Mean	SD	Mean	SD
Content	29.06	6.69	30.24	8.04	32.82	5.44
Attitude	80.82	6.99	82.59	6.92	85.76	5.78

TABLE 2

The t-Values Based on Comparing Scores From Each Administration of The Measures

Test	Pretest vs. Post	Pretest vs. Post	Post Two-weeks vs. Post
	Post Two-weeks	Academic Year	Academic Year
Content	2.65*	5.05**	1.03
Attitude	1.08	2.49*	2.41*

* $p < .05$

** $p < .01$

The results indicate that the teachers made significant gains on the content and attitude measures over the experimental period. As expected the greatest content gains were made during the two-week period of content instruction. Actual gains were probably greater than indicated by the data but the content measure used did not contain items to assess understanding of much of the content covered in the instructional sessions. Of major interest was the indication that the significant positive changes in attitude toward teaching science did not occur during the two-week instructional period, but did occur during the academic year follow-up period when the teachers were probably using the content information in instructing their students. However, tests of linear correlation indicated no relationship between content gains and positive changes in attitude.

Conclusions and Comments

The study results do not provide conclusive evidence that elementary school teachers' attitudes toward teaching science can be changed through instruction in science content related to the content they are expected to teach. However, the fact that greater positive attitude changes occurred during the follow-up in-service period may mean that the increased knowledge of science content along with the follow-up assistance and support facilitated improvements in teachers' attitudes as they were using some of the content in instructing their students. In response to a structured survey instrument administered at the end of the academic year period, the teachers indicated that becoming more knowledgeable about science content and process had made them more confident in teaching science to their students, and consequently they actually taught science more often and more effectively. However, because no direct relationship was found between measured content gains and the attitude changes, other factors such as teaching environment and amount and type of science instruction required locally may have influenced or caused the measured attitude changes.

Further effort is required, using a control group and a larger sample, to provide a more definitive answer to the question addressed to this study. Additionally,

effort is needed to identify effective in-service techniques, methodologies, and content to assist elementary school teachers in improving their teaching of science.

References

- Ankney, Paul and Robert E. Rogers. (1976): Rising to the Challenge. *Science and Children*. 13(5):9-11.
- DeRose, J. V., David Lockard, Lester G. Paldy. (1979): The Teacher is the Key: A Report on Three NSF Studies. *Science and Children*. 16(7):35-41.
- Gabel, Dorothy and Peter Rubba. (1979): Attitude Changes of Elementary Teachers According to the Curriculum Studied During Workshop Participation and Their Role as Model Science Teachers. *Journal of Research in Science Teaching*. 16(1):19-24.
- Moore, R. W. (1975): A Two-year Study of CCSS Group's Attitudes Toward Science and Science Teaching. *School Science and Mathematics*. 76(3):288-290.
- Shirgley, Robert L. (1974): The Correlation of Science Attitude and Science Knowledge of Preservice Elementary Teachers. *Science Education*. 58(2):143-151.
- Spooner, William F. and Ronald D. Simpson. (1979): The Influence of a Five-Day Teachers Workshop On Attitudes of Elementary School Teachers Toward Science and Science Teaching. *School Science and Mathematics*. 79(5):415-420.

The Post-Embryonic Instars of a New Species of *Mydopholeus* (Acari: Astigmata: Rosensteiniidae)

Norman J. Fashing

Department of Biology
College of William and Mary
Williamsburg, Virginia 23185

Abstract—A new species of Rosensteiniidae, *Mydopholeus wrenni*, is established based on specimens collected from bat guano in an Oklahoma cave. All post-embryonic instars are described. The genus *Guanophagoides* Fain and Flechtmann is synonymized with *Mydopholeus* McDaniel and Baker.

Introduction

In 1962 McDaniel and Baker described a new genus and species of Rosensteiniidae, *Mydopholeus capillus*, collected in Jalisco, Mexico. The present paper describes a new species of this genus which was collected in Oklahoma, U.S.A.

Mydopholeus wrenni new species

Relative positions of setae and other structures as indicated in figures. All measurements in micrometers with the mean given first and followed by the range in parentheses.

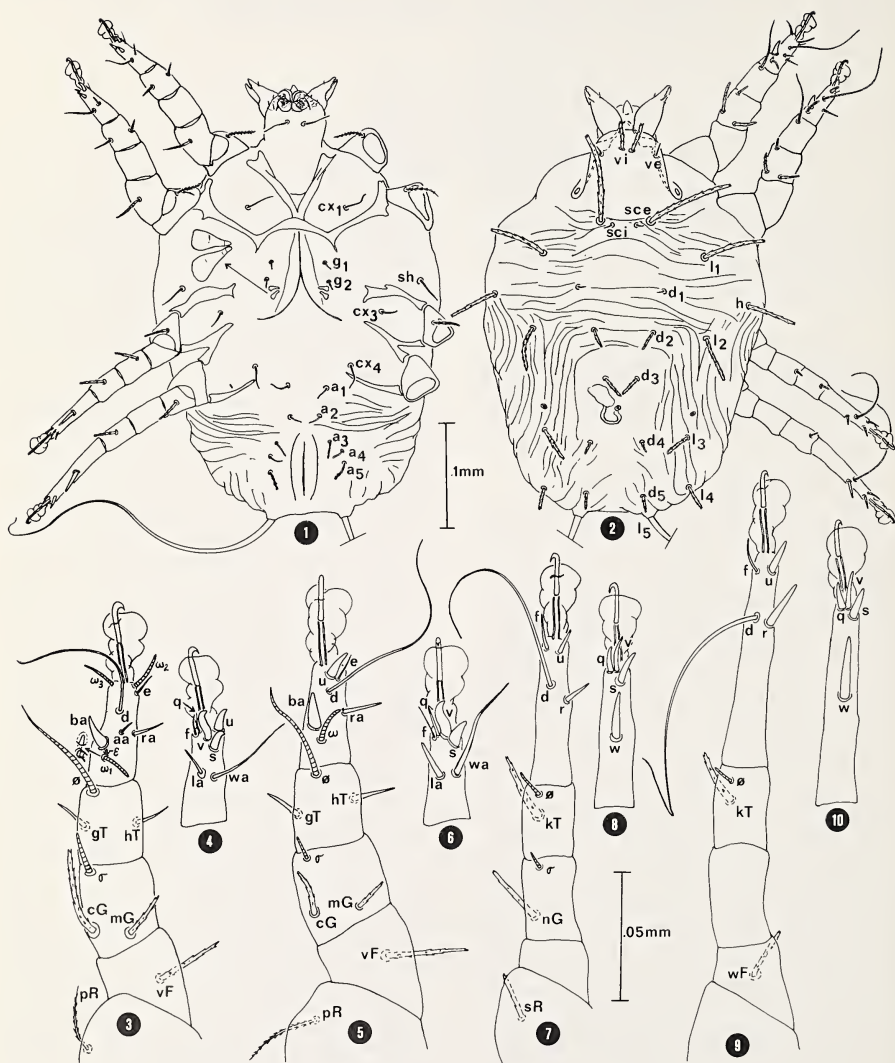
Description of Female (Figs. 1-2) ($n = 6$). Idiosomal length 367 (324-401); width at level of seta *sh* 271 (246-306). Idiosoma oval in outline, broadest anteriorly and narrowing posteriorly. Propodosoma and hysterosoma not divided by sejugal furrow. Dorsal surface striated with the exception of propodosomal region anterior to setae *sc e* (propodosomal shield), and the region anterior to and surrounding setae *d*₃ and extending to setae *d*₅ (on some specimens, a few striations occur between setae *d*₄ and *d*₅). Striations extending to ventral surface posterior to legs IV. Dorsum with 15 pairs of setae: *v i* 29 (24-32), *v e* 10 (8-12), *sc e* 82 (70-92), *sc i* 8 (4-10), *h* 46 (40-49), *l*₁ 54 (49-58), *l*₂ 36 (29-47), *l*₃ 25 (19-29), *l*₄ 22 (16-25), *l*₅ 392 (332-430), *d*₁ 8 (5-10), *d*₂ 17 (12-19), *d*₃ 21 (19-24), *d*₄ 11 (9-15), *d*₅ 18 (17-20). With the exception of setae *v e*, *sc i*, *d*₁ and *l*₅, all dorsal setae cylindrical with barbs (pectinations) along their lengths. Setae *v e*, *sc i*, and *d*₁ short and hairlike, and setae *l*₅ long and whiplike (barbs lacking on both *d*₂ setae of one specimen, both *d*₄ setae of one specimen, one *d*₄ seta of four specimens, and one *d*₅ seta of one specimen; setae *v e* occasionally bifurcate at tip). Supra-coxal setae absent. Opening of bursa copulatrix dorsal and located centrally between setae *d*₃ and *d*₄. Venter of idiosoma with 11 pairs of setae: *sh* 21 (18-23), *cx*₁ 25 (19-30), *cx*₂ 21 (15-25), *cx*₄ 49 (38-52), *g*₁ 10 (8-13), *g*₂ 10 (7-13), *a*₁ 12 (10-16), *a*₂ 12 (10-14), *a*₃ 13 (11-15), *a*₄ 11 (9-13), and *a*₅ 16 (13-19). All setae hairlike with the exception of *sh* which is somewhat stouter and *a*₅ which is pectinate (*a*₃ also

pectinate on two specimens). Apodemes of legs I fused to form a "V", the base of which is fused to the epigynum. Apodemes of legs II unite with epigynum. Oviporus a sharply pointed inverted "V" extending between coxal fields II and III. Genital acetabula small, narrow, and tapering toward tip. Anus a longitudinal slit with lobes on each side, and located on posterior margin of idiosoma.

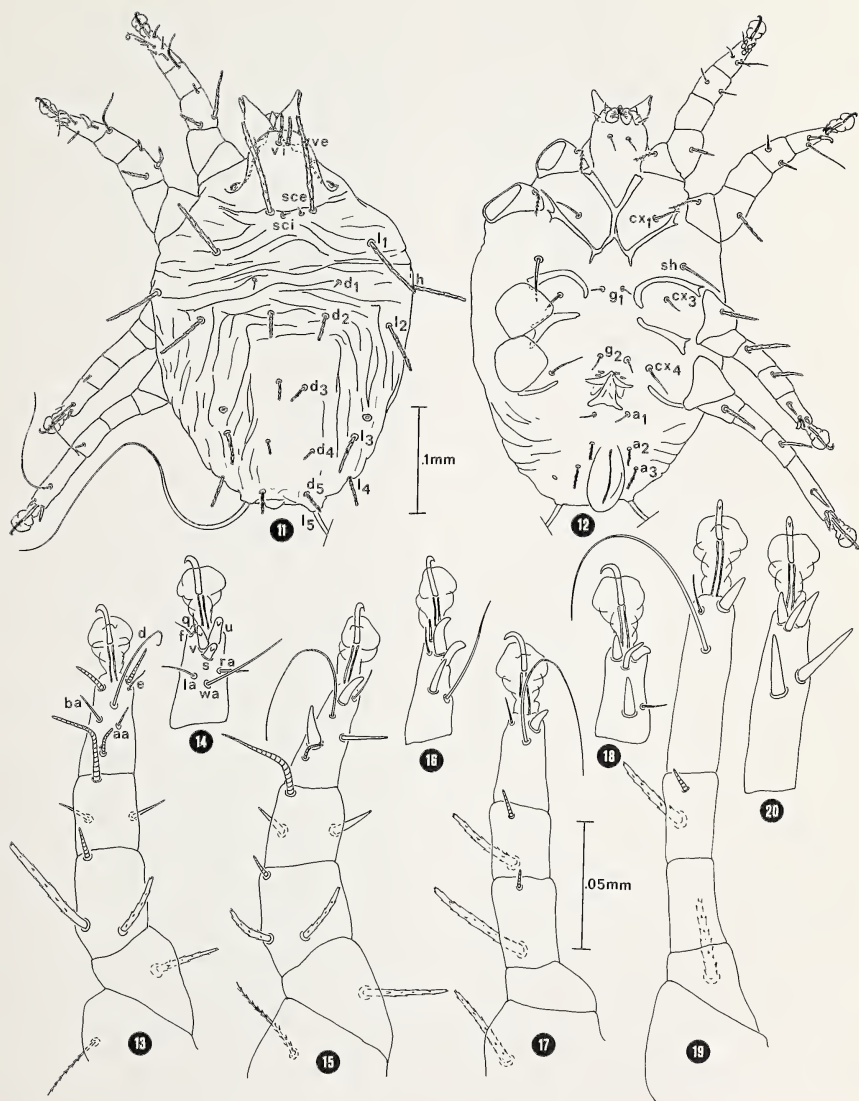
Leg I (Figs. 3-4) with trochanter bearing a thin pectinate seta (*pR*). Femur I with a cylindriciform seta (*vF*) bearing small barbs along its length. Genu I with a single solenidion (*σ*) and two cylindriciform setae (*mG* and *cG*), bearing small barbs. Tibia with a long solenidion (*φ*) and two spinelike setae (*gT* and *hT*). Tarsus with twelve setae and three solenidia. Solenidion *ω*₁ arising dorsally about one fourth of the way up from the base, and solenidia *ω*₂ and *ω*₃ both arising from distal end of tarsus. Famulus (*ε*) small and inserted in a depression in front of *ω*₁. Seta *ba* a stout spine located in front of famulus. Setae *s*, *v* and *u* clawlike and located ventrally and distally. All other setae simple and filiform. Seta *p* absent. Leg II (Figs. 5-6) similar to leg I except tarsus with eleven setae (seta *aa* absent) and seta *u* located dorsally instead of ventrally. Leg III (Figs. 7-8) with maximal setal complement except for absence of tarsal setae *e* and *p*. Setae *sR*, *nG* and *kT* cylindrical and barbed. Leg IV (Figs. 9-10) with maximal setal complement except for absence of tarsal setae *e* and *p*. Setae *wF* and *kT* cylindrical and barbed. Legs I and II stouter than III and IV. Legs I, II and III of approximately the same length, but leg IV longer than others, primarily due to a long, slender tarsus.

Subcapitulum (Fig. 21) and chelicerae (Fig. 22) similar to that found in *M. capillus*. Venter of subcapitulum with a pair of flattened, veined, almost round pseudorutellar processes. Dorsal subcapitular setae (*cd*) short, stout and blunt. A pair of canals run from the podocephalic region through the subcapitulum and appear to empty into the mouth or cibarium.

Description of Male (Figs. 11-12) ($n = 5$). Idiosomal length 367 (349-391); width at level of seta *sh* 242 (232-257). Similar in idiosomal shape, dorsal setal pattern and dorsal striation pattern to female. Fifteen pairs of dorsal setae: *v i* 22 (21-24), *v e* 8 (7-11), *sc e* 83 (57-91), *sc i* 6 (4-7), *h* 64 (57-85), *l*₁ 68 (64-78), *l*₂ 50 (38-63), *l*₃ 30 (22-39), *l*₄ 26 (21-28), *l*₅ 367 (363-377), *d*₁ 6 (6-7), *d*₂ 17 (14-21), *d*₃ 18 (15-21), *d*₄ 9 (8-11) and *d*₅ 21 (18-23). Setae similar in shape and pectinations to



FIGS. 1-10. *Mydopholeus wrenni* female: 1) ventral view, 2) dorsal view, 3) leg I postaxial view, 4) tarsus I preaxial view, 5) leg II postaxial view, 6) tarsus II preaxial view, 7) leg III postaxial view, 8) tarsus III preaxial view, 9) leg IV postaxial view, 10) tarsus IV preaxial view.



FIGS. 11-20. *Myrdopholeus wrenni* male: 11) dorsal view, 12) ventral view, 13) leg I postaxial view, 14) tarsus I preaxial view, 15) leg II postaxial view, 16) tarsus II preaxial view, 17) leg III postaxial view, 18) tarsus III preaxial view, 19) leg IV postaxial view, 20) tarsus IV preaxial view.

those of female. Pectination of setae d_4 variable (three specimens with pectinations only at tip, and one specimen lacking pectinations). Chelicerae and subcapitulum similar to female.

Venter of idiosoma with nine pairs of setae: sh 44 (38-50), cx_1 34 (30-39), cx_3 24 (21-28), cx_4 61 (51-74), g_1 10 (9-13), g_2 11 (9-13), a_1 14 (11-16), a_2 17 (14-21) and a_3 17 (12-21). Coxal setae and setae sh spinelike, a_2 and a_3 thin and pectinate, and others hairlike (a_2 not pectinate on two specimens and a_3 not pectinate on one specimen). Apodemes of legs I fuse to form a "Y-shaped" sternum. Apodemes of legs II join at midline and are in turn fused to base of sternum. Genital apparatus between coxal fields IV. Genital acetabula and anus similar in appearance to female.

Legs (Figs. 13-20) similar in appearance to female except slightly stouter and with many setae being stouter and larger. Seta ba of tarsus I simple and filiform, not a stout spine as in female. Chaetotaxy and solenidiotaxy similar to female.

Description of Larva (Figs. 23-24) ($n = 1$). Idiosomal length 189; width at level of seta sh 154. Idiosoma ovoid, but cleft posterior to anus. Pattern of dorsal striations similar to adult, except longitudinal striations also present centrally at posterior of idiosoma. Dorsum bearing twelve pairs of setae: v i 8, v e 5, sc e 21, sc i 3, h 9, I 9, I_2 8, I_3 5, d_1 3, d_2 5, d_3 5 and d_4 5. Setae similar in appearance to female except d_2 , d_3 , d_4 , I_2 , I_3 and h not pectinate. Setae h with slight bifurcation at tip. Venter bearing four pairs of setae: sh 8, cx_1 12, cx_3 12 and a 6. Apodemes of legs I unite to form a "V-shaped" sternum; apodemes II and III free. Claparede organs absent from coxal fields I. Leg chaetotaxy and solenidiotaxy similar to female except trochanteral setae and tarsal solenidia ω_2 and ω_3 absent.

Description of Protonymph (Figs. 25-26) ($n = 3$). Idiosomal length 241 (200-265); width at level of seta sh 188 (159-203). Idiosoma ovoid with dorsal striations similar to larva. Dorsum bearing 15 pairs of setae: v i 9 (7-12), v e 6 (4-7), sc e 43 (37-50), sc i 4 (4-4), h 13 (13-18), I 25 (20-27), I_2 11 (9-13), I_3 7 (6-7), I_4 6 (6-7), I_5 148 (142-156), d_1 4 (4-5), d_2 5 (4-6), d_3 5 (4-6), d_4 4 (4-5) and d_5 5 (5-6). Setae similar in appearance to female with the exception that setae d_2 , d_3 , d_4 , d_5 , I_3 and I_4 not pectinate (both I_2 setae not pectinate on one specimen, and pectinate on only one of pair on two specimens; setae h with bifurcation at tip on two specimens). Venter bearing seven pairs of setae: sh 9 (6-12), cx_1 14 (11-18), cx_3 12 (9-14), g 7 (7-8), upper anal setae 7 (6-8), middle and lower anal setae 6 (5-6). No anal setae pectinate. Apodemes similar to larva except upper apodemes of leg IV fused at tip with lower apodemes of leg III. Legs I, II and III similar to female but with the absence of setae on trochanters and the absence of solenidium ω_3 on tarsus I. Leg IV without femoral setae, tibial setae, tibial solenidia and tarsal setae e and f . Genital primordia between coxal fields IV.

Description of Tritonymph (Figs. 27-28) ($n = 10$). Idiosomal length 322 (284-375); width at level of seta sh 249 (216-280). Idiosoma ovoid with dorsal striations similar to larva. Dorsum bearing 15 pairs of setae: v i

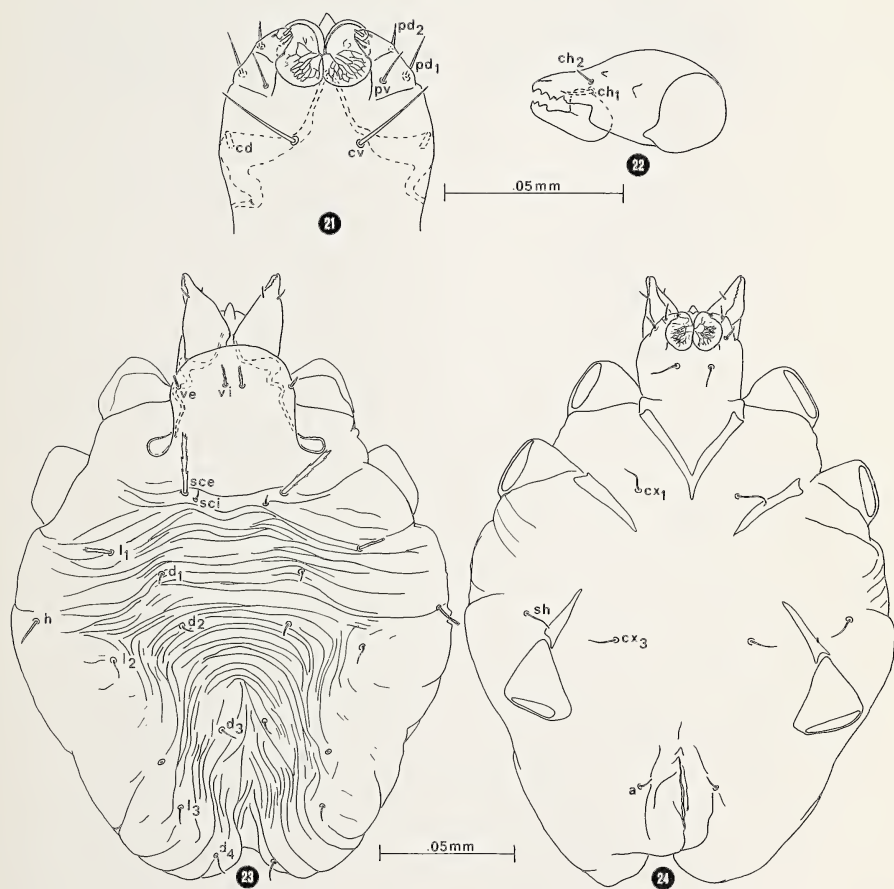
15 (14-18), v e 6 (6-7), sc e 62 (52-71), sc i 4 (3-6), h 26 (20-36), I_1 40 (37-48), I_2 17 (12-23), I_3 12 (8-15), I_4 8 (6-13), I_5 279 (252-326), d_1 4 (3-6), d_2 6 (4-8), d_3 7 (5-8), d_4 6 (4-7) and d_5 6 (4-7). Setae similar in appearance to female with the exception that setae d_2 , d_3 , and d_4 and usually I_4 are not barbed (both setae I_4 barbed on one specimen, only one of pair barbed on one specimen, and both simply bifurcate at tip on one specimen; setae I_3 not barbed on two specimens and barbed on one seta of pair on one specimen). Venter bearing nine pairs of setae: sh 16 (13-22), cx_1 20 (16-25), cx_3 18 (14-22), cx_4 28 (22-43), upper genital setae 7 (7-8), lower genital setae 7 (7-8), upper anal setae 8 (7-9), middle anal setae 8 (6-9) and lower anal setae 7 (6-8). No anal seta pectinate. Apodemes similar to protonymph. Genital primordia between coxal fields IV. Leg chaetotaxy and solenidiotaxy similar to female.

Systematic Position. McDaniel and Baker (1962) described the genus *Mydopholeus* based on a single species (*M. capillus*) collected from the Mexican free-tail bat *Tadarida brasiliensis* (Saussure) near Tamaulapa, Jalisco, Mexico. *Mydopholeus wrenni* shares with *M. Capillus* the following adult characteristics diagnostic of the genus. Tarsal seta ba a strong spine on legs I and II of the female and legs II of the male. Only one solenidium present on genu I. The dorsum of the idiosoma is striated in a characteristic pattern of transverse striations anteriorly and medially and longitudinal and oblique striations laterally. Fifteen pairs of dorsal setae present. The apodemes of legs I and II are fused—apodemes I forming a "V" and apodemes II a "W". Female with a dorsal bursa copulatrix, and the venter of the subcapitulum of both sexes bears a pair of almost circular pseudorutellar processes.

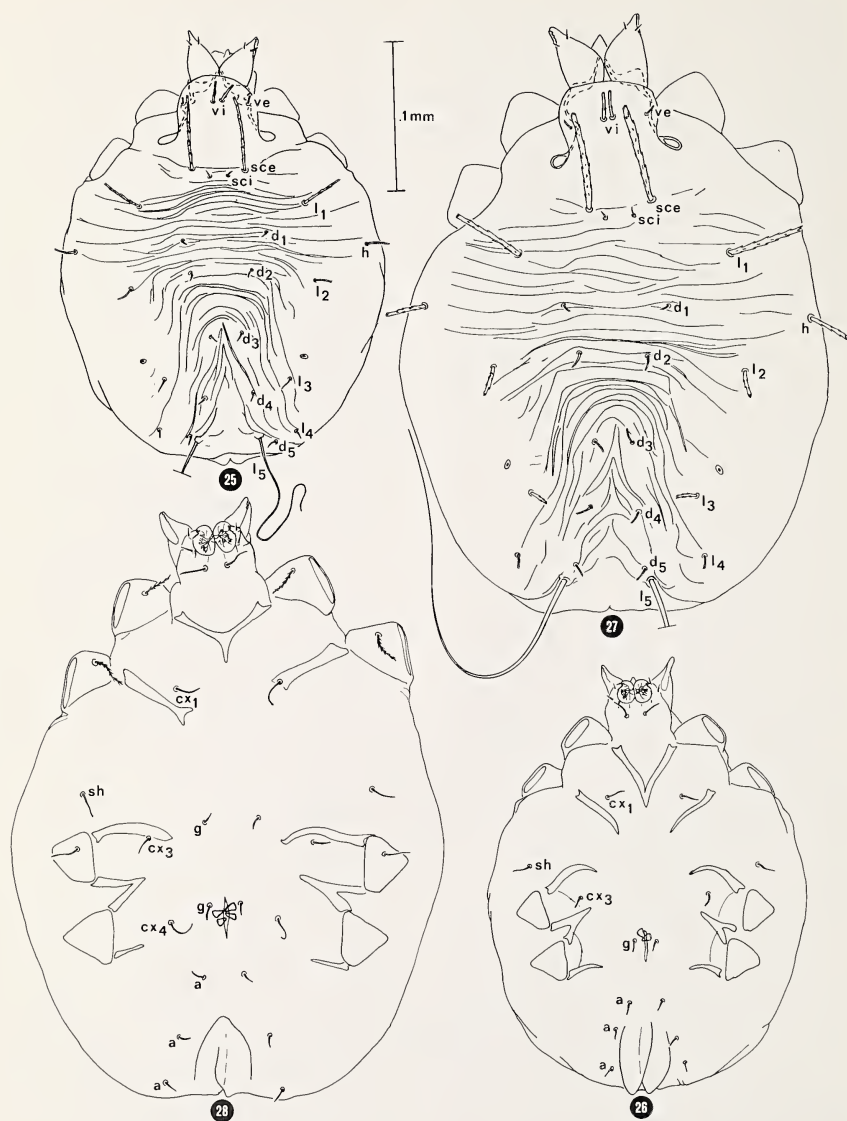
Mydopholeus wrenni differs from *M. capillus* in that dorsal setae d_1 are extremely short, dorsal setae v e, sc i and d_1 are not pectinate, some anal setae are pectinate, and supra-coxal setae are lacking.

In 1978 Fain and Flechtmann established a new genus of Rosensteiniidae, *Guanophagoides*, based on a single species (*G. piracicabensis* Fain and Flechtmann) collected from bat guano in Piracicaba, Brazil. Their generic description is, however, consistent with that for *Mydopholeus* in the diagnostic characteristics cited above. Thus I consider *Guanophagoides* a junior synonym of *Mydopholeus* (NEW SYNONYMY). *Mydopholeus wrenni* differs from *M. piracicabensis* (NEW COMBINATION) in that dorsal setae d_1 are short, dorsal setae v e, sc i and d_1 are not pectinate, the area around setae d_3 and d_4 is free of striations, some anal setae are pectinate, and setae sc e are much shorter (setae sc e are 10 to 20 times longer than sc i in *M. wrenni*, and only four times longer in *M. piracicabensis*).

Habitat, Collection Locality, and Location of Types. *Mydopholeus wrenni* was extracted from bat guano collected in Merihew Cave on Old Merihew Ranch; located six miles south, two miles west of Aetna, Woods Co., Oklahoma. Almost all of the bat guano present in Merihew Cave is the product of Mexican free-tail bats (*T. brasiliensis*).



FIGS. 21-24. *Mydopholeus wrenni*: 21) female subcapitulum, ventral view, 22) female chelicera, 23) larva, dorsal view, 24) larva, ventral view.



FIGS. 25-28. *Mydopholeus wrenni*: 25) protonymph, dorsal view, 26) protonymph, ventral view, 27) tritonymph, dorsal view, 28) tritonymph, ventral view.

The holotype (female) will be deposited in the National Museum of Natural History, Washington, D.C., along with paratypes. Paratypes will also be deposited in the Acarology Laboratory, Ohio State University, Columbus, Ohio, and the Laboratoire de Zoologie Médicale, Institut de Médecine Tropicale, Anvers, Belgium.

Acknowledgements

I am grateful to Dr. William J. Wrenn, University of North Dakota, for collection of the bat guano from which the mites were extracted. *Mydopholeus wrenni* is named in his honor. Special appreciation goes to Dr. Gisela K. Fashing, Department of Public Health,

Newport News, Virginia, and Dr. Barry O'Connor, University of Michigan, for their critical review of the manuscript. In addition I thank Dr. O'Connor for his unpublished observations concerning the type specimens of *Mydopholeus capillus*. This work was supported by a Busch Summer Research Grant and an Alumni Summer Research Grant, both awarded by the College of William and Mary.

Literature Cited

- Fain, A., and Flechtmann, C. H. W. (1978): A new genus and two new species of Nycteriglyphinae from bat guano in Brazil (Acari, Astigmata). *Rev. Brasil. Biol.* 38, 555-558.
- McDaniel, B., and Baker, E. W. (1962): A new genus of Rosensteiniidae (Acarina) from Mexico. *Fieldiana* 44, 127-131.

The Species of *Rhododendron* Native to North America¹

Martha K. Roane

Department of Plant Pathology and Physiology
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

and

Josephine DeN. Henry

Henry Foundation for Botanical Research
Gladwyne, Pennsylvania 19035

Abstract—The evergreen and deciduous species of *Rhododendron* native to North America are widespread throughout the area but do not occur in the Great Plains, Interior Plains, and Mexico. The highest species concentration is in eastern North America and centers in Virginia and North Carolina. Descriptions and keys of the species are provided.

Introduction

The *Rhododendrons* of North America are representatives of an old group of plants with floral parts typical of primitive angiosperms. Members of the genus existed in North America fifty million years ago in essentially the same form as those found today in the wild in Asia (Leach, 1961). According to Cronquist (1968), the family Ericaceae and order Ericales, to which the genus *Rhododendron* L. belongs, are found in the subclass Dilleniidae, one of four subclasses probably derived directly from the Theales and indirectly through the Theales from the Dilleniales, the order in the subclass most closely related to the Magnoliales of the Magnoliidae. The name *Rhododendron* is derived from the Greek words *rhodon* (rose) and *dendron* (tree) and was used by Pliny to describe the oleander (*Nerium oleander* L.). It took on its present meaning when Linnaeus (1754) established the genus *Rhododendron*. As it is known today, the genus consists of about 1000 species that vary from tiny mats two inches high to giant trees (Leach, 1961). Ninety percent of the world's *Rhododendrons* are concentrated in southeastern Asia from the northwestern Himalayas, Tibet, western and central China, southward to Malaysia and the Philippine Islands.

In North America, the twenty-seven native species occur in the arctic-alpine areas of Canada and Alaska, along the Sierra Nevada and Cascade Ranges as far south as southern California and along the Rocky Mountains into Colorado. They are not found in the Great Plains, Interior Plains or in Mexico but appear again in the Ouachita belt in Missouri, Oklahoma and Arkansas, the Interior Plateau from Tennessee north into New York, the Coastal Plain from southeastern Texas through the Mississippi Embayment and north into New England and Piedmont. The highest concentration of species is in eastern North America and

centers in Virginia and North Carolina. The narrowest endemic, *R. vaseyi* A. Gray, is restricted to the higher mountains of western North Carolina at altitudes between 3000 and 5500 feet. The native *Rhododendrons* are mainly inhabitants of the temperate deciduous forests and most are found on the wooded acidic slopes of hills and mountains, although *R. roseum* (Loisel.) Rehd. and *R. oblongifolium* (Small) Millais do grow on limestone soil. The separation of the North American and Asiatic species has been attributed to continental drift and/or land bridges that have recently subsided. In North America the separation of the western and eastern species probably is due to the formation of mountain ranges during the late Tertiary and the glacial period (Lee, 1965).

The data in this paper have been compiled from field observations and collections, herbarium specimens, and literature (Duncan & Pullen, 1962; Funk & Fuller, 1978; Hulten, 1968; Hitchcock et al., 1969; Munz, 1963; Peck, 1961; Read & Wrzesinski, 1978; Rehder, 1927; Roane, 1975; Rydberg, 1922; Shiskin & Bobrov, 1967; Small, 1914, 1933; Solymosy, 1976; Viereck & Little, 1972; Wilson & Rehder, 1921; Wood, 1961).

Rhododendron Linnaeus

Evergreen or deciduous shrubs with alternate, entire or ciliateserrulate, glabrous to tomentose, lepidote or strigose leaves. Buds with several to many imbricate scales. Flowers 5-merous, usually in terminal corymbs. Calyx 5-parted, often very small, persistent. Corolla white to yellow or orange, pink, purple or deep red, rotate to campanulate, or funnelliform, usually irregular, with a 5-lobed limb, the median lobe adaxial; deciduous. Stamens 5-10, usually exserted from the corolla. Ovary superior, 5-locular. Fruit, a septicidal 5-loculed capsule, usually ovoid to oblong, 0.5-1 cm or more long.

Footnote

¹Contribution No. 398, Department of Plant Pathology and Physiology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Key to Flowering Plants

1. Leaves evergreen, glabrous, lepidote or tomentose, not ciliate 2
1. Leaves deciduous, pubescent, often strigose and ciliate, never lepidote 8
 - 2(1). Plants lepidote 3
 - 2(1). Plants not lepidote 6
- 3(2). Flowers 2.5-5 cm across, corolla campanulate-funnelform, erect shrubs 4
- 3(2). Flowers 1-2 cm across, corolla rotate-campanulate; procumbent, depressed or suberect-depressed shrub
 1. *R. lapponicum*
 - 4(3). Flowers opening after the leafy shoots of the season expanded 4
 - 4(3). Flowers opening before or with the expanding leafy shoots of the season 5
 - 5(4). Tubes magenta, lobes rose with magenta spots on largest lobe; filaments white; anthers magenta
 2. *R. chapmanii*
 - 5(4). Tubes and lobes pale rose-purple; rarely white, usually not spotted; filaments pale pink; anthers pale yellow
 3. *R. carolinianum*
 - 6(2). Calyx lobes much shorter than ovary, underside of leaves glabrous 7
 - 6(2). Calyx lobes as long as ovary, underside of leaves tomentose or pubescent
 5. *R. maximum*
 - 7(6). Pedicels glabrous, corolla rosy-purple with red-brown spots
 6. *R. macrophyllum*
 - 7(6). Pedicels pubescent, corolla lilac-purple with olive-green spots
 7. *R. catawbiense*
 - 8(1). Stamens 10, in one case, 5-7; corolla rotate to rotate-campanulate, sometime two-lipped 9
 - 8(1). Stamens 5, corolla funnelform, subregular 12
 - 9(8). Inflorescences axillary or lateral; corolla rotate-campanulate, not two-lipped, not divided to the base
 8. *R. albiflorum*
 - 9(8). Inflorescences terminal; corolla irregular, two-lipped or divided to the base on the lower side 10
 - 10(9). Procumbent shrubs, flowers solitary or two together
 9. *R. camtschaticum*
 - 10(9). Erect shrubs, inflorescences with three or more flowers 11
 - 11(10). Stamens 10; corolla two-lipped with two lower lobes divided to the base, rose-purple, not spotted
 10. *R. canadense*
 - 11(10). Stamens 5-7; corolla with short tube, slightly two-lipped, pink or white, with orange or red-orange spots
 11. *R. vaseyi*
 - 12(8). Flowers yellow or orange to scarlet or red, rarely white or pink; corolla slightly subirregular with the uppermost lobe the largest; often with a conspicuous yellow or orange blotch on the largest lobe 13
 - 12(8). Flowers white to deep pink, carmine or crimson; corolla regular; usually with no conspicuous blotch 18
 - 13(12). Corolla abruptly dilated, tube longer than lobes 14
 - 13(12). Corolla gradually dilated, tube as long as lobes 15
 - 14(13). Flowers opening before leaves expand; tube glandular, purple or red; lobes yellow
 12. *R. austrinum*
 - 14(13). Flowers opening with the leaves, tube glandless, tube and lobes unicolorous, red to scarlet
 15. *R. flammecum*
 - 15(13). Corolla white or pink, style and filaments white
 14. *R. occidentale*
 - 15(13). Corolla yellow, orange, scarlet or red; style and filaments not white 16
 - 16(15). Filaments twice as long as tube, tube strongly ridged, calyx lobes ciliate
 13. *R. bakeri*
 - 16(15). Filaments three times as long as tube, tube not strongly ridged, calyx lobes glandular-ciliate 17
 - 17(16). Corolla 5 cm or more across, style and filaments yellow to orange, flowers opening with the leaves
 16. *R. calendulaceum*
 - 17(16). Corolla 3.5-4 cm across, style and filaments brick red, flowers opening when leaves are about fully developed
 17. *R. cumberlandense*
 - 18(12). Corolla without prominent rows of glands along large veins of lobes 19
 - 18(12). Corolla with prominent rows of glands along large veins of lobes 22
 - 19(18). Winter buds glabrous 20
 - 19(18). Winter buds pubescent 21
 - 20(19). Leaves glabrous; corolla tube pink, about as long as the lobes; filaments almost three times as long as tube; flowers not fragrant
 19. *R. nudiflorum*
 - 20(19). Leaves pubescent beneath; corolla tube white, longer than lobes, filaments twice as long as tube; flowers fragrant

20. *R. alabamense*
21(19). Filaments twice as long as corolla tube; lobes about as long as tube; entire corolla usually bright pink, rarely white; with clove-pink fragrance
21. *R. roseum*
21(19). Filaments almost three times as long as corolla tube; lobes half as long as tube; tube usually deeper pink than lobes; flowers fragrant but not like clove-pink
22. *R. canescens*
22(18). Low, stoloniferous shrubs with simple or little-branched stems usually less than 0.5 m tall; leaf blades and petioles with short, stipitate glands
18. *R. atlanticum*
22(18). Much branched shrubs usually more than 0.5 m tall; leaf blades and petioles glandless 23
23(22). Branchlets pubescent; style pubescent 24
23(22). Branchlets glabrous; style glabrous 26
24(23). Leaves 4-10 cm long; calyx lobes oblong to oblong-lanceolate, unequal, 1-3 mm long
23. *R. oblongifolium*
24(23). Leaves 2-6 cm long; calyx lobes semi-orbicular to ovate, short, equal, 1 mm long 25
25(24). Branchlets yellow or gray-brown, hirsute or moderately strigose; corolla slightly pubescent inside above the middle
24. *R. viscosum*
25(24). Branchlets bright red-brown, copiously strigose, finely villous; corolla tube glabrous inside
25. *R. serrulatum*
26(23). Corolla white or pink; tube glandular-pilose outside; flowers fragrant;
26. *R. arborescens*
26(23). Corolla crimson; tube glabrous outside; flowers not fragrant
27. *R. prunifolium*
2. *R. chapmanii*
5(4). Low compact shrubs to 2 m; leaves elliptic to narrow-elliptic, somewhat broadened upward, 5-8 cm long; capsules oblong-ovoid, 8-12 mm long
3. *R. carolinianum*
5(4). Straggling shrubs to 3 m; leaves narrow-elliptic to lanceolate, not broadened upward, 4-10 cm long; capsules oblong, less than 8 mm long
4. *R. minus*
6(2). Pedicels glandular or pubescent 7
6(2). Pedicels glabrous
6. *R. macrophyllum*
7(6). Capsules and pedicels glandular
5. *R. maximum*
7(6). Capsules and pedicels pubescent
7. *R. catawbiense*
8(1). Twigs glabrous; leaves glabrous or sparingly strigose on lower midrib 9
8(1). Twigs pubescent and/or strigose; leaves pubescent, more or less strigose, sometimes stipitate-glandular 10
9(8). Capsules densely glandular
26. *R. arborescens*
9(8). Capsules strigose, minutely pubescent
27. *R. prunifolium*
10(8). Capsules axillary
8. *R. albiflorum*
10(8). Capsules terminal 11
11(10). Plants to 35 cm tall, capsule to 1 cm long; pedicels to 3 cm long
9. *R. camtschaticum*
11(10). Plants to 1 m or more tall; capsule length to 1.5 cm or more; pedicel length 2 cm or less 12
12(11). Capsules glandular 13
12(11). Capsules without glands 23
13(12). Leaves usually glandular 14
13(12). Leaves usually eglandular 17
14(12). Petioles usually glabrous, eglandular
11. *R. vaseyi*
14(12). Petioles usually pubescent, stipitate-glandular 15
15(14). Buds glabrous; shrubs stoloniferous, to 0.5 m tall
15. *R. atlanticum*
15(14). Buds pubescent; shrubs not stoloniferous, more than 0.5 m tall 16
16(15). Buds pink, twigs yellow-red or pink, shrubs to 1 m tall
10. *R. canadense*
16(15). Buds gray, twigs red-brown, shrub to 3 m tall
12. *R. austrinum*
17(13). Buds usually glabrous 18
17(13). Buds usually trichotomous 21
18(17). Twigs strigose, not pubescent; shrubs stoloniferous 19
- Key to Plants with Leaves and Capsules**
1. Leaves evergreen, glabrous, lepidote, or tomentose, not ciliate 2
1. Leaves deciduous, glabrous, or pubescent, often strigose and ciliate, never lepidote 8
2(1). Leaves lepidote 3
2(1). Leaves glabrous 6
3(2). Shrubs erect, capsules to 12 mm long 4
3(2). Shrubs procumbent, depressed or suberect-depressed; capsules 4-5 mm long
1. *R. lapponicum*
4(3). Leaves up to 13 cm long, blades acute or acuminate 5
4(3). Leaves 2-5 cm long, blades obtuse or retuse

- 18(17). Twigs strigose and pubescent; shrubs not stoloniferous 20
- 19(18). Leaves trichomatous; petioles villous and strigillose 20. *R. alabamense*
- 19(18). Leaves glabrous; petioles strigillose, not villous 24. *R. viscosum*
- 20(18). Petioles pubescent; capsule strigose, glandular; buds yellow with no brown margin 13. *R. bakeri*
- 20(18). Petioles strigose; capsules villous, glandular-setose; buds yellow-brown with sharply marked dark brown marginal band 25. *R. serrulatum*
- 21(17). Petioles pubescent; pedicels pubescent, eglandular 23. *R. oblongifolium*
- 21(17). Petioles strigose, pubescent; pedicels pubescent, glandular 22
- 22(21). Bud scales acuminate, aristate-mucronate, finely pubescent; leaves thinly pubescent on both surfaces 14. *R. occidentale*
- 22(21). Bud scales mucronulate, densely gray pubescent; leaves sparingly pubescent above and densely gray villous beneath 21. *R. roseum*
- 23(12). Buds gray, densely pubescent 22. *R. canescens*
- 23(12). Buds not gray, glabrous 24
- 24(23). Leaves pubescent, strigose; pedicels eglandular, strigose 25
- 24(23). Leaves pubescent, not strigose; pedicels setulose, stipitate-glandular 16. *R. calendulaceum*
- 25(24). Capsules strigose, finely pubescent; leaves strigillose 19. *R. nudiflorum*
- 25(24). Capsules strigose, not pubescent; leaves strigose, pubescent 26
- 26(25). Pedicels strigose, pubescent; twigs yellow-brown, sparingly strigose or glabrous 17. *R. cumberlandense*
- 26(25). Pedicels strigose, not pubescent; twigs orange-brown densely strigose, finely pubescent 15. *R. flammula*

1. *Rhododendron lapponicum* (L.) Wahl. Fl. Suec. p. 249. 1824.
Azalea lapponica L. Sp. Pl. 1:151. 1753.
 Lapland Rose Bay. Alpine *Rhododendron*.

Matted to erect much branched shrub 1-4 cm tall. Twigs stout, brown, densely lepidote. Bud scales rosy purple, densely lepidote. Bud scales rosy purple, den-

sely lepidote, mucronate, white ciliolate. Leaves oblong, elliptic or oval, to 1.5 cm long, obtuse, leathery, slightly revolute, densely lepidote, slightly paler beneath than above. Petioles lepidote, 0.5-1 mm long. Flowers in clusters of 1 to several, pink to deep purple, sometimes white, fragrant. Pedicels lepidote, 6-12 mm long. Calyx lobes minute, ovate to oblong-ovate, lepidote, long-ciliate. Corolla rotate-campanulate, 1.5-2 cm dia, 7-10 mm long, slightly hairy at base within, with rather deeply cut oblong lobes. Stamens 5-8(-10), much exserted; filaments pink to purple, gently curved, hairy only at the base, 1-1.5 cm long; anthers short, cylindric, ochraceous, 1 mm long. Style pink to purple, gently curved, slightly exceeding stamens. Capsules ovoid or ovoid-oblong, lepidote, rusty, to 7 mm long.

Occasional to rare shrubs of tundra and open spruce forests at tree line. Circumboreal in North America from Greenland, Labrador, Baffin Island, Ellesmere Island, Canadian Arctic, the mountains of south central Alaska west to the Arctic coast and north slope of Brooks Range. Absent from the northern coastal plain of Alaska. Also disjunct locations in the Gaspé, Maine, Wisconsin and the mountains of New York, New England. June to August.

2. *Rhododendron chapmanii* A. Gray. Proc. Acad. Phila. 11. 4:61. 1877.
Azalea chapmanii (A. Gray) Kuntze. Rev. Gen. Pl. 2:387. 1891.
Rhododendron minus Michx. var. *chapmanii* (A. Gray) Duncan & Pullen. Brittonia 14:297. 1962.

Evergreen shrubs usually 1 m tall, rarely to 2 m, with erect rigid branches. Twigs gray-yellow, rusty-lepidote. Buds gray-orange with rusty-lepidote, white-ciliolate, mucronate, obovate scales. Leaves coriaceous, revolute, oblong to oval, 2-5 cm long, obtuse or retuse at apex, abruptly narrowed at base, somewhat lustrous above, lepidote beneath. Petioles short, to 3 mm long, lepidote. Flowers several, in an umbel-like cluster, appearing before leafy shoots of the season, tubes magenta, lobes rose with magenta spots on largest lobe, not fragrant. Pedicels densely lepidote, 0.5-1 cm long. Calyx lobes broadly deltoid, less than 1 mm long, densely lepidote with long delicately white-ciliolate margin. Corolla 2.5-3 cm long, 3 cm dia, funnellform-campanulate; tube to 1 cm long and 5 mm wide; lobes oblong-ovate, to 1 cm long. Stamens 10; filaments white, more than 2.5 cm long; anthers magenta, less than 2.5 mm long. Style magenta, shorter than stamens. Capsules brown, densely lepidote, cylindric, to 1 cm long.

Low pinelands of western Florida. Late March.

3. *Rhododendron carolinianum* Rehder. Rhodora 14:99. 1912.
Rhododendron punctatum Small, Fl. S.E. U.S. p. 884. 1903. (non Andrews)
Rhododendron carolinianum var. *margarettae* Ashe. Rhodora 23:177. 1921.
Rhododendron carolinianum var. *album* (Rehder) Rehder. Jour. Arnold Arb. 4:250. 1923.

Rhododendron carolinianum var. *foliatum* Rehder. Jour. Arnold Arb. 7:33. 1926.

Rhododendron minus Michx. var. *minus* Duncan & Pullen. Brittonia 14:297. 1962.

Low compact shrubs with thick branches. Twigs green- or purple-lepidote. Buds ovoid, acute, with broadly ovate, mucronate, densely white-ciliate, lepidote scales. Leaves coriaceous, oval or elliptic to elliptic-oblong, broadly cuneate at the base, acute or shortly acuminate at the apex, 5-8 cm long and 2.5-4 cm broad, above at first lepidote but soon becoming glabrous, somewhat lustrous, deep yellow-green, paler beneath and densely, or sometimes more sparsely, lepidote, slightly revolute at the margin; midrib above slightly, beneath strongly elevated. Petioles stout, relatively long, lepidote, slightly pubescent, 0.5-1.5 cm long. Flowers 4-9 in dense umbel-like terminal racemes, pale rose-purple, rarely white, usually not spotted, opening when young shoots are scarcely developed, not fragrant. Pedicels 1-1.5 cm long, lepidote. Calyx lobes semi-orbicular or broadly ovate, 2-3 mm long, lepidote on margin and outside. Corolla rotate-campanulate, 2.5 cm long and 3.5-4 cm wide, glabrous or sparingly lepidote outside; lobes broadly ovate, about as long or slightly longer than the short gradually widened tube. Stamens 10, slightly shorter than the corolla; filaments pale pink, villous at base, 1-2.5 cm long; anthers pale yellow, 2-3 mm long. Style glabrous, purple, slightly shorter than stamens. Capsules narrow-oblong, 8-12 mm long, 2-4 mm thick, brown, lepidote.

In full bloom in early May when buds of *R. minus* are still tightly closed. Higher mountains of North Carolina, South Carolina, and Tennessee.

4. *Rhododendron minus* Michx. Jour. Hist. Nat. 1:412. 1792.

Rhododendron punctatum Andr. Bot. Reposit. 36. 1798.

Rhododendron parviflorum Hort. ex DC. Prodr. 7:723. 1839.

Azalea minor (Michx.) Kuntze. Rev. Gen. Pl. 2:386. 1891.

Branching, straggling evergreen shrubs 2-3.5 m tall. Twigs sparingly lepidote, villous. Buds densely lepidote with mucronate, white-ciliate scales. Leaves deep green and glabrous above, paler green, densely lepidote and often glabrous beneath, mostly at the ends of branches, narrow elliptic to lanceolate, 4-10 cm long, acute or somewhat acuminate at both ends. Petioles stout, more or less pubescent, lepidote, 3-12 mm long. Flowers opening after leaves have unfolded, in clusters of 7-10, clear rose spotted with green, sometimes white, rarely with yellow blotch on upper lobe, not fragrant. Pedicels densely lepidote, to 1.5 cm long. Calyx lobes lepidote, deltoid, delicately long-ciliate, broader than long, to 2 mm long. Corolla funnelliform-campanulate, 2-3 cm long, 2-3 cm dia, lobes usually flat but rarely crisped. Stamens 10, unequal; longer filaments exceed 2.5 cm; anthers ochraceous, 2.5 mm

long. Style purple, 2-2.5 cm long. Capsules oblong or oblong-ovoid, lepidote, 8-12 mm long.

Woodlands of inner Coastal Plain to lower Blue Ridge of North Carolina to Georgia and Alabama. Late May, June.

5. *Rhododendron maximum* L. Sp. Pl. 1:392. 1753.

Rhododendron purpureum G. Don. Gen. Hist. 3:843. 1834.

Rhododendron purshii G. Don. Gen. Hist. 3:843. 1834.

Rhododendron ashleyi Coker. Jour. Elisha Mitchell Sci. Soc. 51:189. 1935.

Hymenanthus maxima (L.) Copeland. Amer. Midland Nat. 30:614. 1943.

Rhododendron maximum var. *leachii* Harkness in Leach, Rhododendrons of the World. p. 192. 1961. Rose Bay. Great Laurel. White Laurel.

Evergreen shrubs or small trees to 10 m tall. Twigs gray-brown, scurfy. Buds with red-brown, tomentose, ciliate scales. Leaves thick, coriaceous, bright green above, pale green beneath, oblong-obovate, 10-20 cm long, abruptly narrowed or tapering at the base, glabrous above, almost imperceptibly scurfy beneath. Petioles stout, scurfy, 2-4.5 cm long. Flowers opening after the new leaves expand, numerous, in an umbel-like cluster, white to rose, with yellow or orange spots, somewhat green in throat, not fragrant. Pedicels stipitate-glandular, 3-4 cm long. Calyx lobes ovate to oblong, mostly longer than wide, 2-4 mm long. Corolla rotate to campanulate, 2-3 cm long, 3.5-4 cm dia, lobes not crisped. Stamens 10, unequal, the longer filaments to 2 cm long, anthers 2 mm long. Style shorter than stamens. Capsules stipitate-glandular, narrowly oblong or cylindric-oblong or slightly narrowed upward, 1-1.5 cm long.

In woodlands, on northern slopes and shady mountainsides, in sheltered stream valleys. Nova Scotia to southern Ontario and Ohio, south, especially in the mountains, to Georgia and Alabama. June, July.

6. *Rhododendron macrophyllum* G. Don. Gen. Hist. Pl. 3:843. 1834.

Rhododendron californicum Hook. Curtis' Bot. Mag. 81: pl 4836. 1855.

Hymenanthus californicus (Hooker) Copeland. Amer. Midland Nat. 30:614. 1943.

Rhododendron macrophyllum f. *album* Rehder. Jour. Arnold Arb. 28:254. 1947.

Hymenanthus macrophyllum (G. Don) Copeland. Leaflet West. Bot. 5:140. 1948.

Hymenanthus macrophyllum f. *album* (Rehder) Copeland. Leaflet West. Bot. 5:140. 1948.

Western Rose Bay. California Rose Bay.

Evergreen shrubs 1-5 m tall with coarse glabrous branches. Twigs puberulent when young, then glabrate and coarse. Buds glabrous with long-awned scales. Leaves coriaceous, dark green above, paler and somewhat papillose beneath, oblong to elliptic, 6-20 cm long. Petioles stout, glabrous, 1-2 cm long. Flowers many, in terminal clusters, white to pink or rose-purple

with red-brown spots on upper lobes, not fragrant. Pedicels glabrous, 1.5-5 cm long. Calyx very shallowly lobed, glabrous, lobes 1 mm long and considerably broader, margin entire. Corolla tubular-campanulate, 2.5-4 cm long, glabrous, deeply 5-lobed, lobes ovate, spreading, crisped-undulate. Stamens 10, unequal, the longer ones well exserted; filaments white, sparsely short-trichomed on the lower half, 1-3.5 cm long; anthers pale yellow or pale pink, oblong, 2-3 mm long. Style pale pink or rose-purple, glabrous, as long as stamens. Ovary and young capsule strigose, stipitate-glandular. Mature capsules ovoid to oblong, woody, 1.5-2 cm long.

Dryish to damp, more or less shaded woods below 4000 feet from Vancouver Island and southern British Columbia along the coast of Washington and Oregon into northern California. April-July.

7. *Rhododendron catawbiense* Michx. Fl. Bor. Am. 1:258. 1803.

Hymenanthus catawbiensis (Michx.) Copeland. Amer. Midland Nat. 30:614. 1943.

Mountain Rose Bay. Purple Laurel. Rose Bay. Catawba Rhododendron.

Evergreen shrubs or small trees to 6 m tall. Twigs gray to red-brown, scurfy. Bud scales red-brown, slightly scurfy, glandular-ciliate. Leaves thick, coriaceous, dark green above, pale green beneath, oval or elliptic, 5-15 cm long, broadest near the middle, rounded, obtuse or subacute at both ends, sometimes subcordate at the base, abruptly pointed at apex, glabrous on both sides, aciliate, midribs sparingly hirsutulous. Petioles sparingly hirsutulous, stout, 1.5-2.5 cm long. Flowers many, in an umbel-like cluster, somewhat larger than those of *R. maximum*, rose-purple to lilac, rarely white, with olive-green spots on upper lobe, not fragrant. Pedicels 2.5-3.0 cm long, hirsutulous, eglandular. Calyx lobes broadly triangular or semicircular, broader than long, less than 1 mm long. Corolla rotate to campanulate, glabrous, to 6 cm dia. Stamens 10, to 3 mm long; filaments purple, anthers white, 2-3 mm long. Style about as long as stamens, purple. Capsules cylindric, 2-2.5 cm long, densely hirsute, eglandular.

Mountains of Virginia and West Virginia to Georgia and Alabama, rarely eastward to near the Coastal Plain. May, June.

8. *Rhododendron albiflorum* Hook. Fl. Bor. Am. 2:43. 1834.

Azalea albiflora Kuntze. Rev. Gen. 2:387. 1891.

Azaleastrum albiflorum (Hook.) Rydb. Mem. N.Y. Bot. Gard. 1:297. 1900.

Deciduous shrubs with erect branches, 1-2 m tall. Twigs finely puberulent, copiously red strigose-hirsute, glandular-strigose. Bud scales thin, caducous, strigose-hirsute. Leaves alternate, clustered or approximate on young shoots, thin, deep green above, lighter beneath, elliptic-oblancoate, entire to undulate, 4-9 cm long, slightly ciliate, appressed-pilose and copiously strigose-hirsute, midribs appressed-villous. Petioles

pubescent, strigose, 5-10 mm long. Flowers white or ochroleucous with yellow spots, in axillary clusters of 1-4 along the stems, not fragrant. Pedicels stipitate-glandular, coarsely red-hirsute, 1-1.5 cm long. Calyx divided to base; lobes oblong, ovate or obovate, finely pubescent, red-hirsute, stipitate-glandular, ciliate, to 1 cm long. Corolla rotate or rotate-campanulate, 1-1.5 cm long, with very broad lobes about as long as the tube. Stamens 10, exserted, 1-1.5 cm long, with lower half of white filaments very pubescent, anthers obovoid or globoid, yellow, 1-2 mm long. Style white, pubescent at base, as long as filaments. Capsules ovoid, 6-10 mm long, heavy-walled, pubescent.

Wet places, usually along streams, chiefly montane. British Columbia south to Oregon and east to western Montana and Colorado. June through August.

9. *Rhododendron camtschaticum* Pall. Fl. Ross. 1:48. 1784.

Rhododendron camtschaticus Lindl. Paxt. Fl. Gard. 1:pl 22. 1853.

Chamaecistus kamtschaticus Rgl. Dendrol. III:196. 1873.

Therorhodion camtschaticum (Pall.) Small. N. Amer. Fl. 29(1):45. 1914.

Therorhodion glandulosum Standley. N. Amer. Fl. 29(1):45. 1914.

Rhododendron kamtschaticum var. *pumilum* E. Busch. Fl. Sib. and Dal'm Vost. II:37. 1915.

Rhododendron kamtschaticum var. *pallasianum* Kom. Fl. Kamtsch. II:360. 1929.

Rhododendron kamtschaticum ssp. *typicum* Hult. Flora Kamtsch. IV:14. 1930.

Rhododendron kamtschaticum ssp. *glandulosum* (Standley) Hult. Flora Kamtsch. IV:14. 1930.

Rhododendron kamtschaticum ssp. *intercedens* Hult. Flora Kamtsch. IV:14. 1930.

Kamchatka Rhododendron.

Deciduous shrubs to 3 cm tall, with depressed stems, much branched, with leaves approximate in rosettes at ends of branches, spreading underground by means of suckers. Twigs gray-brown to red-brown, coarse, sparingly glandular-pilose, with long scattered trichomes. Buds yellow-brown, glabrous, scales thin, persistent, mucronate, strigose, ciliate. Leaves cuneate to obovate or oval, 1-4 cm long, obtuse or rounded, mucronulate at apex, bristly-ciliate, glandular-ciliate, sparingly pilose and strigose on veins beneath, sessile. Flowers opening with the leaves, rose-purple, with deeper rose-purple spots, very rarely white, 1-3, terminating leafy shoots, not fragrant. Pedicels 1 cm or more long, glandular-pilose with 2 foliaceous bracteoles. Calyx lobes oblong-oval, 1-2 cm long, glandular-pubescent, bristly-ciliate. Corolla rotate, 2.5-5 cm dia. glabrous to pubescent, deeply lobed; tube to 5 mm long; lobes erose, often ciliate, two-lipped, lower lip deeply cleft, 2-2.5 cm long. Stamens 10, unequal; filaments purple, villous at base, shorter than corolla, lower 5 twice as long as upper 5; anthers oval or obovoid, purple. Style villous at base, exceeding stamens, purple. Capsule ovoid, thin-walled, villous, sub-

coriaceous, 5-10 mm long.

Dry rocky tundra of Aleutian Islands and alpine zone of forested regions of Alaska. June through August.

10. *Rhododendron canadense* (L.) Torr. Geol. Survey New York Assembly, No. 50. 1839. Cat. Pl. p. 151.
Rhodora canadensis L. Sp. Pl. Ed. 2. 1:561. 1762.
Hoehenwartia canadensis Crantz. Inst. II:469. 1766.
Rhododendron rhodora G. F. Gmelin. Syst. Nat. II pt. 1:694. 1791.
Rhodora congesta Moench. Meth.:68. 1794.
Rhododendron pulchellum Salisb. Prodr.:287. 1796.
Azalea canadensis (L.) O. Kuntze. Rev. Gen. II:386. 1891.
Rhodora.

Much branched deciduous shrubs to 1 m tall, with slender upright or ascending branches. Twigs puberulous, bright yellow-red or pink, often slightly bloomy. Buds finely pubescent with ovate, acuminate to acute, pink, ciliate scales. Leaves elliptic to oblong, obtuse or acute, cuneate at base, 2-4.5 (-6) cm long; with ciliate and revolute margin; dull blue-green, somewhat strigillose, with finely villous midribs above; thinly gray-tomentulose, with scattered fulvous trichomes and short stipitate glands, sparingly strigose midribs beneath. Petioles puberulous, sparingly strigose, 2-5 mm long. Flowers opening before leaves in 3-7-flowered umbel-like racemes, rose-purple, not fragrant. Pedicels puberulous, glaucous, sparingly glandular-pilose, 3-7 mm long. Calyx lobes very short, unequal, puberulous, setosely-ciliate. Corolla glabrous, 1.5-2 cm long, two-lipped, the lower lip divided nearly to the base into two nearly distinct narrow-oblong lobes, the upper lip with three short ovate lobes. Stamens 10, unequal, about as long as corolla; filaments pubescent on lower third, purple; anthers broadly ellipsoidal, purple, 2 mm long. Style slightly longer than stamens, 1.5-2 cm long, glabrous or minutely pilose at base, purple. Capsules ovoid-oblong, curved near the base, slightly grooved, setose, finely puberulous, sparingly short stipitate-glandular, light red-brown with a pink bloom, 1-1.5 cm long.

River banks, moist woods and swamps from Labrador and Newfoundland to southwestern Quebec and south through New England, central New York to northeastern Pennsylvania and northern New Jersey. April-May; June in the north.

11. *Rhododendron vaseyi* A. Gray. Proc. Amer. Acad. XV:48. 1879.
Azalea vaseyi (Gray) Rehder. Möller's Deutsch. Gärt.-Zeit. XIV:332. 1899.
Biltia vaseyi (Gray) Small. FL. S.E. U.S. p. 884. 1903.
Pinkshell Azalea.

Deciduous, upright, irregularly branched shrubs with spreading branches, to 5 m tall, not stoloniferous. Twigs light red-brown, puberulous, sparingly pilose, glabrescent. Buds with orbicular-ovate, mucronulate

scales, outer acuminate, glabrous, inner ones minutely puberulous, white-ciliate, sometimes glandular-ciliate. Leaves elliptic, elliptic-oblong, acuminate, cuneate, 5-12 cm long, 2-5 cm broad; margins ciliate, usually slightly undulate; glabrous above and sparingly short stipitate-glandular near midribs beneath; midribs sparingly finely-villous above and sparingly pilose beneath. Petioles glabrous or sparingly pilose, 3-7 mm long. Flowers opening before leaves, in 5-8 flowered racemes, white or light rose with orange or red-orange dots, not fragrant. Pedicels short stipitate-glandular, 0.5-1.5 cm long. Calyx oblique with shallow, rounded lobes erose-glandular on margins. Corolla rotate-campanulate, 2.5-3 cm long, two-lipped, glabrous; tube very short, to 5 mm long; lobes oblong, rounded at apex, upper lip less deeply divided, with middle lobe exterior in bud. Stamens usually 7, sometimes 5 or 6, unequal, the longer exceeding the corolla; filaments glabrous, white or pink; anthers ellipsoid, white, pink, or purple, 1-2 mm long. Style glabrous or with a few stipitate glands near the base, white, longer than stamens, 2.5-3 cm long. Capsules narrow-oblong, with thin narrow keel on back of valves, stipitate-glandular, 1-1.5 cm long.

Mountain slopes and summits. North Carolina. May.

12. *Rhododendron austrinum* (Small) Rehder in Bailey, Stand. Cycl. Hort. VI:3574. 1917.
Rhododendron nudiflorum var. *luteum* Curtiss in Rehder, A Monograph of Azalea. p. 146. 1921.
Azalea austrina Small. FL. S.E.U.S. Ed. 2. p. 1356. 1913.
Florida Azalea.

Deciduous shrubs to 3 m tall, with irregular branches, not observed to be stoloniferous. Twigs reddish-brown, with soft puberulence, sparingly strigose, copiously stipitate-glandular. Buds with ovate, acuminate scales, densely gray-pubescent. Leaves elliptic to obovate or oblong-ovate, 3-9 cm long, acute or obtuse and mucronulate at apex, cuneate at base, setosely ciliate or glandular-ciliate, finely pubescent on both sides but pubescence denser on lower. Petioles pubescent and stipitate-glandular, sparingly strigose, 3-8 mm long. Flowers opening before or with leaves, yellow to orange with no yellow to orange blotch, the tube more or less purple, slightly fragrant, in 8-15-flowered umbel-like racemes. Pedicels pubescent, glandular-setose, 0.5-1 cm long. Calyx lobes broadly ovate to oblong, unequal, 1-2.5 mm long, glandular-ciliate, pubescent. Corolla funneliform; tube 1.5-2 cm long, cylindric, abruptly dilated at apex, finely pubescent, stipitate-glandular; lobes 1-1.5 cm long, short-acuminate with recurved points, finely pubescent outside. Stamens three times as long as tube, filaments pubescent below the middle, anthers ochraceous, 2-3 mm long. Style slightly exceeding stamens, 5-6 cm long, short-pilose near base. Capsules oblong-cylindric, 1.5-2.5 cm long, with thin, fine pubescence, long-strigose, partly long-tipped trichomes.

River banks and sometimes flood plains. Originally reported from Gadsden and Liberty Counties in Flor-

ida but also from Georgia, Alabama and Mississippi. Late April.

13. *Rhododendron bakeri* (Lemmon & McKay) Hume. Azaleas, Kinds and Culture. p. 28. 1949.

Azalea bakeri Lemmon & McKay. Bartonian 19:16-17. 1938.

Deciduous shrubs or small trees regularly to 3 m tall, with irregularly whorled branches, not stoloniferous. Twigs light green, puberulent, sparingly strigose. Buds yellow, conical; scales glabrous, ciliate, mucronate or awned; awn shorter than body of scale. Leaves narrowly to broadly elliptic, acute, mucronulate; 2-8 cm long, ciliate; blades glabrous or pubescent above, glabrous, shiny or pubescent beneath; midribs strigose above and pubescent and strigose beneath; veins strigillose beneath. Petioles pubescent, 2-5 mm long. Flowers in clusters of 3-9, expanding after leaves, yellow or red-orange with no distinct yellow to orange blotch, not fragrant. Pedicels villous, stipitate-glandular, 2-6 mm long. Calyx lobes unequal, elliptic-acuminate to deltoid-ovate, setose, ciliate. Corolla funnelform, 5-6 cm dia; tube strongly ridged, pubescent, stipitate-glandular, gradually dilated, 1.5-2.5 cm long; lobes ovate to elliptic, acute, slightly pubescent and stipitate-glandular, 1.5-2.5 cm long. Stamens 5, exserted; filaments more than twice the length of the tube with the exserted portion glabrous, carmine and the remainder pubescent, lighter; anthers ochraceous, 2 mm long. Style carmine, with pubescent base, 7.5 cm long. Capsules cylindric, strigose with appressed gland-tipped trichomes, 1.5 cm long.

Blue Ridge Mountains of Georgia and North Carolina above 3000 feet, June-August.

14. *Rhododendron occidentale* (Torr. & Gray) A. Gray. Bot. Calif. 1:458. 1876.

Azalea calendulacea Hooker & Arnott. Bot. Capt. Beechey Voy. 362. 1841. (not Michaux)

Azalea nudiflora var. *ciliata* Kellogg. Proc. Calif. Acad. Sci. 1:60. 1855.

Azalea californica Torrey & Gray. Durand, Jour. Acad. Philadelphia. Ser. 3, III:94. 1855. (not *R. californicum* Hooker)

Azalea occidentalis Torrey & Gray. Rev. Explor. Surv. Miss. Pacif. Ocean IV:116. 1856.

Rhododendron sonomense Green. Pittonia II:172. 1891.

Western Azalea. Pacific Azalea.

Deciduous shrubs to 3 (-5) m tall with loose branching, shredding bark. Twigs stiff, divaricate, glabrous to pubescent, sometimes stipitate-glandular, brown. Buds finely pubescent or nearly glabrous with ovate to ovate-lanceolate, acuminate, aristate-mucronate or mucronulate scales. Leaves elliptic, oblong-lanceolate, 3-9 cm long, acute or obtuse, mucronulate, cuneate or attenuate at base, ciliate, thinly pubescent on both surfaces, rarely nearly glabrous; midribs pubescent above, sparingly strigose beneath. Petioles rather stout, short, pubescent, strigose, 1-5 mm long. Flowers opening with or after leaves, 5-20 in umbel-like

racemes, white to pink with yellow blotch, usually not fragrant. Pedicels pubescent, more or less glandular, sometimes pilose, eglandular, rarely nearly glabrous, to 1.5 cm long. Calyx lobes broadly ovate to oblong-ovate, obtuse, 1.5-5 mm long, densely ciliate with usually setose gland-tipped or glandless hairs. Corolla funnelform, somewhat irregular; tube narrowly funnelform, gradually dilated upward, villous, glandular-pilose, 2-3 cm long; lobes about as long as tube, broad-ovate, acute. Stamens 5, exserted, more than twice tube length; filaments pilose below middle, white; anthers white, 2.5-3 mm long. Style as long or longer than stamens, white, pubescent above base. Capsules ovate-oblong, setosely pilose, stipitate-glandular, 1-2 cm long.

Moist thickets and stream banks among the mountains to 5800 feet elev. Oregon, California. June, July; rarely as early as April or as late as mid-August.

15. *Rhododendron flammeum* (Michx.) Sargent. Rhododendron Soc. Notes 1(3):120. 1917.

Azalea nudiflora coccinea Aiton. Hort. Kew. 1:202. 1789.

Azalea coccinea Curtis. Bot. Mag. 5, t. 180. 1792.

Azalea fulva Michaux. Jour. Hist. Nat. 1:410. 1792.

(nom. nud.)

Azalea calendulacea α *flammea* Michaux. Fl. Bor.

-Am. 1:151. 1803.

Azalea speciosa Willdenow. Berl. Baumz. Ed. 2:49.

1811.

Azalea periclymenoides var. *coccinea* Pursh. Fl.

Am. Sept. 1:152. 1814.

Azalea nudiflora Loiseleur-Deslongchamps. Herb.

Amat. IV:213, t. 1820. (not Linnaeus)

Azalea coccinea major Loddiges. Bot. Cab. VII; t.

624. 1822.

Azalea speciosa α *major* Sweet. Hort. Brit. p. 265.

1826.

Rhododendron speciosum α *major* Sweet. Hort.

Brit. Ed. 2. p. 343. 1830.

Rhododendron nudiflorum ζ *coccineum* Sweet.

Hort. Brit. Ed. 2. p. 343. 1830.

Azalea speciosa α *coccinea* DeCandolle. Prodr.

VII:717. 1839.

Azalea calendulacea Darby. Bot. S. States p. 422.

1855. (in part)

Rhododendron calendulaceum Chapman. Fl. S.

U.S. p. 265. 1860. (in part)

Rhododendron calendulaceum f. *speciosum* Voss.

Vilmorin's Blumengart. 1:588. 1894.

Oconee Azalea.

Deciduous shrubs to 2 m tall with slender, irregularly whorled branches, stoloniferous. Twigs finely pubescent, densely strigillose, trichomes rust-brown; branches orange-brown becoming gray to dark brown-gray, somewhat decorticating. Buds glabrous with scales ovate, mucronate, sometimes aristate, to 3 mm long, ciliate. Leaves obovate, elliptic or oblong, acute or obtuse, mucronulate, broad-cuneate at base, 3-6 cm long, 1-2 (-3) cm broad; strigillose, sometimes glabrescent above, finely pubescent, densely pubescent

on veins, strigose on midribs beneath; setosely ciliate. Petioles pubescent, strigillose, 3-5 mm long. Flowers opening with the leaves in 6-15-flowered umbel-like racemes, scarlet or bright red with large orange blotch on upper lobe, not fragrant. Pedicels strigillose, eglandular, 6-12 mm long. Calyx lobes round-ovate to oblong, long-ciliate, pubescent or nearly glabrous, 0.5-3 mm long. Corolla funnelliform, 3-5 cm dia; tube cylindric, rather slender, 2-2.5 cm long, longer than lobes, abruptly dilated at apex, villous, pilose, occasionally sparsely stipitate-glandular; lobes ovate, abruptly acuminate, 1.5-2 cm long. Stamens 5, much exserted, more than twice as long as tube; filaments pubescent below middle, rose-pink; anthers ochraceous to yellow, to 2 mm long. Style slightly longer than stamens, finely pubescent on lower third, usually purple above. Capsules ovoid to narrow-oblong, narrowed toward apex, strigose, 2-3 cm long.

Dry open woods and sand hills. Piedmont of South Carolina, Georgia. Late April, early May.

16. *Rhododendron calendulaceum* (Michx.) Torr. Fl. U.S. p. 425. 1824.

Azalea lutea L. Sp. Pl. 1:150. 1753. (in part)

Azalea nudiflora L. Sp. Pl. Ed. 2. 1:214. 1762. (in part)

Azalea flammea Bartram. Travels 1:327. 1791. (nom. nud.)

Azalea calendulacea Michx. Fl. Bor. Am. 1:151. 1803. (excluding var. α)

Azalea aurantiaca Dietrich. Darst. Verz. Zierpfl. 4. t. 1. 1803.

Azalea pontica β *A. calendulacea* Persoon. Syn. 1:212. 1805.

Rhododendron luteum (L.) Schneider. Ill. Handb. Laubholz. 11:500, fig. 329 q-r, 320a. 1911. (not Sweet)

Flame Azalea. Yellow Azalea.

Deciduous shrubs 1.5-3 (-5) m tall, with erect and spreading branches, not observed to be stoloniferous. Twigs gray-brown, strigose with fine dense pubescence. Buds glabrous, brown with broadly ovate, apiculate, densely white-ciliate scales. Leaves oblong to obovate or lanceolate, ciliate, 4-8 cm long, acute, mucronulate, broadly cuneate at base, finely pubescent above, densely pubescent beneath when young, particularly on and along the midribs. Petioles pubescent, 2-5 mm long. Flowers expanding with or shortly after the leaves, in clusters of 5-7, yellow or orange to scarlet, with orange blotch on upper lobe, not fragrant. Pedicels setulose, stipitate-glandular, 0.5-1 cm long. Calyx lobes oblong to ovate, obtuse, setulose, glandular-ciliate, 2-3 mm long. Corolla funnelliform, over 6 cm dia; tube gradually dilated above the middle, 1.5-2 cm long, glandular-pilose and pubescent; lobes ovate, undulate, abruptly contracted into short points, slightly pubescent outside, 2 cm long, 1.5 cm broad. Stamens 5, nearly 3 times as long as tube; filaments yellow to orange, pubescent toward the base; anthers yellow to orange, 3 mm long. Style yellow to orange, pilose toward base, 6-7 cm long, as long or longer than

stamens. Capsules ovoid-oblong, 1.5-2 cm long, setose, pubescent.

Appalachian mountain region from Pennsylvania to northern Georgia in open woods and along streams. May-June.

17. *Rhododendron cumberlandense* Braun. Rhodora 43:33. 1941.

Red Azalea. Cumberland Azalea.

Deciduous compactly-growing shrub to 3 m tall but usually lower growing, sometimes stoloniferous. Twigs yellow-brown, sparsely strigose or glabrous. Buds glabrous, yellow-brown with ciliate, mucronate inner scales, outer scales with awn as long as body of scale. Leaves narrowly obovate, 3-5 cm long, less than half as wide, glabrous, full grown at anthesis; midribs strigose with fine white pubescence above, sparingly strigose, finely pubescent beneath. Petioles strigose, pubescent, 3-5 mm long. Flowers opening after leaves are expanded, several in a short raceme, orange-red to red with large orange blotch, not fragrant. Pedicels strigose, finely pubescent, 3-7 mm long. Calyx lobes round-ovate, sparsely hirsute, glandular-ciliate, less than 1 mm long. Corolla 3.5-4 (-5) cm dia, funnelliform, pubescent, strigillose, with short almost sessile glands outside; tube 1-2 cm long, gradually dilated; upper lobe broader than laterals, sometimes twice as broad, almost orbicular but contracted to a short acuminate tip. Stamens 5, exserted; filaments brick red, nearly glabrous, 3 times as long as tube; anthers ochraceous, 1-2 mm long. Style brick red, glabrous, 6-7 cm long. Capsules ovoid, strigose, to 2 cm long.

Mesophytic oak woods. Cumberland and Kanawha Plateaus, Cumberland Mountains of Virginia, Kentucky, Tennessee. June.

18. *Rhododendron atlanticum* (Ashe) Rehder in Wilson & Rehder. A monograph of Azalea. p. 147. 1921.

Azalea atlantica Ashe. Bull. Charleston Mus. XIII:26. 1917.

Dwarf Azalea. Coast Azalea.

Low, stoloniferous, deciduous shrubs rarely more than 0.5 m tall, with slender upright usually sparingly branched or simple stems. Twigs red-brown, glabrous to sparingly strigillose and sometimes setosely glandular. Buds light brown, glabrous or slightly silky pubescent; scales ovate, mucronulate, white-ciliate. Leaves obovate to oblong-ovate, bright green or bluish-green, 3-6 cm long, setosely-ciliate, glabrous above except sometimes short stipitate-glandular, glabrous or short stipitate-glandular beneath; midribs villous above, sparingly strigose, sometimes pubescent, short stipitate-glandular beneath. Petioles sparingly strigillose, short stipitate-glandular, 1-5 mm long. Flowers opening before or with the leaves, white usually flushed pink or purple, no blotch present, in clusters of 4-10, very fragrant. Pedicels to 1 cm long, hirsute, stipitate-glandular. Calyx lobes broadly ovate, glandular-ciliate, 2-4 mm long. Corolla funnelliform, 4 cm dia; tube cylindric, gradually dilated at apex, 2-2.5 cm long with

numerous short gland-tipped trichomes, otherwise glabrous or slightly villous; lobes ovate to ovate-oblong, acute 1.3-2 cm long, prominently stipitate-glandular along the middle. Stamens 5, twice as long as the tube, filaments white to pale buff, villous below middle, anthers white to pale buff, 2-3 mm long. Style exceeding stamens, 4.5-5.5 cm long, pubescent below the middle, purple above. Capsules ovoid-oblong, setose, stipitate-glandular, 1.5-2 cm long.

Coastal Plain pine barrens, Delaware to South Carolina. Late April, early May.

19. *Rhododendron nudiflorum* (L.) Torr. Fl. U.S. p. 424. 1824.

Azalea lutea L. Sp. Pl. 1:150. 1753. (in part)

Azalea nudiflora L. Sp. Pl. Ed. 2. 1:214. 1762. (in part)

Rhododendron venustum Salisbury. Prodr. p. 287. 1796. (in part)

Azalea periclymenoides Michaux. Fl. Bor.-Am. 1:151. 1803.

Azalea periclymena Persoon. Syn. 1:212. 1805.

Azalea nudiflora periclymenoides (Michx.) Heynhold. Nomencl. Bot. Hort. 1:108. 1840.

Anthodendron nudiflorum (L.) Reichenbach in Moessl. Handb. Gewächsk. Ed. 2. 1:309. 1827.

Rhododendron periclymenoides (Michx.) Shinn. Castanea 27: 95. 1962.

Wild Azalea. Early Azalea. Pinxterflower. Pinxterflower. Honeysuckle. Pinxterbloom Azalea.

Deciduous, upright shrubs, 1-2 (-3) m tall with irregularly whorled, intricate branching, occasionally stoloniferous. Twigs slightly pubescent, sparingly strigose. Buds glabrous or slightly pubescent, brown, with ovate, abruptly acuminate, finely ciliate scales. Leaves elliptic, oblong, obovate or oblong-obovate, acute or abruptly acuminate, rarely obtuse, mucronate, finely ciliate, 3-8 cm long, 1.5-3 cm wide, glabrous except for finely pubescent midribs above, strigillose and sometimes pubescent midribs beneath. Petioles strigillose, sometimes slightly pubescent, 2-4 mm long. Flowers opening before or with expanding leaves in clusters of 6-12 or more, white to pink or pink-purple, without blotch, not fragrant. Pedicels strigose-pilose, sometimes finely pubescent, rarely sparingly stipitate-glandular, 4-6 mm long. Calyx lobes semi-orbicular or ovate, long-ciliate, 0.5-2 mm long. Corolla funnel-form, 3.5-5 cm dia; tube gradually dilated above, finely pubescent, pilose or strigose-pilose, sometimes stipitate-glandular, 1.5-2 cm long; lobes ovate to oblong-ovate, abruptly acuminate, finely pubescent to glabrescent outside, 1.2-1.6 cm long. Stamens 5, nearly 3 times tube length; filaments pubescent below middle, white, 4-6 cm long; anthers yellow-brown or yellow-orange, 2-2.5 mm long. Style 5-6 cm long, exceeding stamens, finely pubescent on lower third, usually purple above. Capsules oblong to narrow-oblong, narrowed upward, finely pubescent, usually strigose, 1-2 cm long.

Moist or dry open woods, bogs, along mountain streams, chiefly in Appalachian Mountains to 3800 feet elev. but extending into Piedmont and Coastal

Plain, Massachusetts to North Carolina, from the Atlantic coast west to central New York, Pennsylvania, southern Ohio, eastern Kentucky, also Calloway County in western Kentucky, eastern Tennessee. April, May.

20. *Rhododendron alabamense* Rehder in Wilson & Rehder. A monograph of Azalea. p. 141. 1921.

Azalea nudiflora var. *alba* Mohr. Pl. Life Ala. p. 653. 1901. (not Pursh)

Low deciduous shrubs 1-1.5 m high, with irregularly whorled branches, stoloniferous. Twigs gray or yellow-brown, densely or sparingly strigose. Buds brown, glabrous, with ovate, mucronate, densely white-ciliate scales. Leaves obovate, elliptic to elliptic-oblong or obovate-oblong, base cuneate, apex mucronate, 3-6 cm long, 1-3 cm wide, finely strigillose and sparingly puberulous above, glaucescent or pale green and densely short-villous beneath; midribs villous above and sparingly strigose beneath. Petioles short, rarely over 5 mm long, villous, strigillose. Flowers opening with expanding leaves, in umbel-like racemes of 5-15, white, white with yellow blotch, shades of yellow, white with shades of pink and rose, pink, intensely fragrant. Pedicels villous, stipitate-glandular, rarely eglandular, to 1.5 cm long. Calyx lobes unequal, round to ovate, 0.5-1.5 mm long, densely setose, eglandular. Corolla funnel-form with cylindric tube, gradually dilated at apex, 2-3 cm long, stipitate-glandular or hirsute outside; lobes ovate, acute, 1.5-2 cm long, distinctly shorter than tube, not undulate. Stamens 5, twice as long as tube; filaments white, villous on lower half; anthers yellow, 2-3 mm long. Style exceeding the stamens by 1 cm, finely villous at base, white. Capsules cylindric-oblong, finely villous, stipitate-glandular or eglandular and strigose, 1.5 cm long.

Very steep slopes, rocky hillsides in deciduous or open mixed forests in light, well-drained soil. Alabama, Georgia, South Carolina. April, May.

21. *Rhododendron roseum* (Loisel.) Rehder in Wilson & Rehder. A monograph of Azalea. p. 138. 1921.

Azalea rosea Loiseleur-Deslongchamps in Duhamel, Traité Arb. Arbust. Ed. 2, v. 224, t. 64. 1812.

Azalea canescens Pursh. Fl. Am. Sept. 1:152. 1814. (in part)

Azalea nudiflora \leftrightarrow *rosea* Sweet. Hort. Brit. p. 265. 1826. (nom. nud.).

Azalea nudiflora Darlington. Fl. Cestrica p. 26. 826.

Rhododendron nudiflorum \leftrightarrow *roseum* Sweet.

Hort. Brit. Ed. 2 p. 344. 1830.

Rhododendron nudiflorum (Darlington) Darlington. Fl. Cestrica Ed. 2 p. 262. 1837. (not Torrey)

Rhododendron canescens Porter. Bull. Torr. Bot. Club XVI:220. 1889. (not Sweet)

Azalea prinophylla Small. N. Am. Fl. 29(1):42. 1914.

Rhododendron prinophyllum (Small) Millais. Rhododendrons. p. 229. 1917.

Election Pink. Early Azalea. Mountain Azalea. Rose-shell Azalea.

Deciduous, upright shrubs 1-3 (-5) m tall with irregularly whorled branches, stoloniferous. Twigs gray-brown to light brown, finely pubescent, sparingly strigose, sometimes stipitate-glandular. Buds gray, pubescent, with generally ovate, obtuse, mucronulate, ciliate scales 1 cm long. Leaves elliptic, obovate, obovate-oblong, acute or short-acuminate, cuneate at base, 3-7 cm long, 1-3 cm broad, ciliate, usually eglandular but sometimes stipitate-glandular, sparingly pubescent above, densely gray-villous beneath; midribs pubescent above, sparingly strigillose, sometimes stipitate-glandular beneath. Petioles soft-pubescent, sparingly strigose, 2-5 mm long. Flowers expanding with leaves, in clusters of 5-9, bright pink to magenta, rarely white, without blotch, with clove-pink fragrance. Pedicels finely villous, glandular-setose, 0.5-1.5 cm long. Calyx lobes semi-orbicular to ovate, unequal, finely pubescent, glandular-ciliate, scarcely exceeding 1 mm long. Corolla funnel-form with oblique limb; tube cylindric, gradually dilated toward apex, with thin villous tomentum interspersed with numerous gland-tipped trichomes of unequal length, 1.5-2 cm long; lobes as long as or slightly shorter than tube, ovate, abruptly pointed. Stamens 5, slightly over twice tube length; filaments yellow-brown, pubescent below middle; anthers ochraceous, to 2 mm long. Style purple above, sparingly or densely pubescent below, exceeding stamens, 4-5 cm long. Capsules oblong, narrowed toward apex, sparingly puberulous, setosely glandular, 1.5-2 cm long.

Moist or dry woods or stream banks in Appalachian and Ozark Mountains. Southwestern New Hampshire, central Vermont, southwestern Quebec through New York, western and central Massachusetts, northwestern Connecticut, northern Rhode Island, Pennsylvania, northern New Jersey to eastern Ohio, southwestern Virginia; also western Tennessee, west central Arkansas, south and southeast Missouri, eastern Oklahoma. May, June.

22. *Rhododendron canescens* (Michx.) Sweet. Hort. Brit. Ed. 2 p. 343. 1830.

Azalea lutea L. Sp. Pl. 1:150. 1753. (in part)

Azalea nudiflora L. Sp. Pl. Ed. 2. 1:214. 1762 (in part)

Azalea nudiflora ϵ *bicolor* Aiton. Hort. Kew. 1:203. 1789.

Azalea canescens Michx. Fl. Bor.-Am. 1:150. 1803.

Azalea bicolor Pursh. Fl. Am. Sept. 1:153. 1814.

Rhododendron bicolor Sweet. Hort. Brit. Ed. 2. p. 344. 1830.

Rhododendron nudiflorum (L.) Chapman. Fl. S. U. S. p. 265. 1865. (not Torrey)

Azalea nudiflora var. *canescens* Rehder in Bailey, Cycl. Am. Hort. 1:12. 1900. (in part)

Wild Azalea. Piedmont Azalea. Florida Azalea. Wild Honeysuckle. Hoary Azalea.

Deciduous shrubs to 4 or 5 m tall with irregularly whorled upright branches, stoloniferous. Twigs yellow-brown, finely pubescent, sparingly strigose. Buds densely gray-pubescent, with broadly ovate, acuminate

late scales. Leaves oblong-ovate to oblanceolate or oblong, rarely elliptic or obovate, acute, rarely obtuse, mucronulate, cuneate at base, 4-9 cm long, setosely ciliate; above, sparingly pubescent or glabrescent with finely villous midrib; below, densely pubescent or gray-tomentose with densely pubescent, sparingly strigose midribs. Petioles finely pubescent, sparingly strigose, 2-7 mm long. Flowers expanding before or with leaves in 6-15-flowered clusters, pink with tube usually deeper pink than the lobes which may be almost white, slightly fragrant. Pedicels villous-pubescent, hirsute, sometimes stipitate-glandular, 0.5-1 cm long. Calyx lobes unequal, semi-orbicular to ovate, scarcely exceeding 1 mm, ciliate or glandular-ciliate. Corolla funnel-form, to 4 cm dia; tube cylindric, abruptly dilated at apex, 1.5-2.5 cm long, sometimes nearly twice as long as lobes, densely and finely villous, stipitate-glandular; lobes ovate, acute or obtuse, 1.2-1.5 cm long, no yellow to orange blotch. Stamens 5, much exerted, nearly 3 times the tube length, with pink filaments pubescent below the middle, ochraceous anthers 1.5-2 mm long. Style pink, finely villous toward base, 4-6 cm long, as long or longer than stamens. Capsules cylindric-oblong, narrowed upward, slender, pubescent, sparingly setose, 1.5-2 cm long.

Moist sandy soil, often along streams. Southern Atlantic and Gulf Coastal Plain from Virginia to Florida and west to Oklahoma, southeastern Texas; Piedmont of Virginia, North Carolina, Georgia, Tennessee, Mississippi Embayment. April, May, sometimes as early as January.

23. *Rhododendron oblongifolium* (Small) Millais. *Rhododendrons*. p. 219. 1917.

Azalea oblongifolia Small. Fl. S. E. U. S. p. 883, 1336. 1903.

Texas Azalea.

Deciduous shrub 2 m tall or less, with irregularly whorled branches, sometimes stoloniferous. Twigs with short, sparse villous pubescence, sparingly strigose, sometimes nearly glabrous, orange-brown. Buds with ovate, acuminate or obtuse, gray-pubescent scales. Leaves obovate, elliptic-obovate, oblong-oblanceolate, rarely oblong, 4-10 cm long, 1.5-4 cm broad, acute, mucronulate, cuneate, ciliate; dull green, glabrous, sometimes strigillose, minutely pubescent above, light green, rarely glaucescent, more or less pubescent or nearly glabrous beneath; midribs villous above, pilose and strigillose beneath. Petioles finely pubescent, 2-3 mm long. Flowers expanding after the leaves in 7-12-flowered clusters, white, no blotch, fragrant (lemon oil scent). Pedicels sparingly villous, glandular-hirsute, 5-7 mm long. Calyx lobes unequal, ovate, oblong, lanceolate, obtuse to acute, 1-3 mm long, long ciliate, sparingly villous. Corolla funnel-form; tube cylindric, 2.5-3 cm long, abruptly dilated at apex, thinly villous, sparingly glandular-hirsute; lobes oblong-ovate, acute, 1.5-2 cm long; stipitate-glandular along middle. Stamens 5, twice as long as tube, slightly exceeding lobes; filaments white, villous below middle; anthers ochraceous, 2.5-3 mm long. Style exceeding

stamens, 5-6 cm long, finely pubescent at lower third or sometimes glabrous, white. Capsules oblong, ovoid-oblong, or narrow-oblong, finely villous, stipitate-glandular, 1-2 cm long.

Sandy soils along high stream banks, open woods, occasionally in sandy, freshwater bogs, on slopes with exposed rocks. Arkansas, Louisiana, Oklahoma, Texas. Late April, May.

24. *Rhododendron viscosum* (L.) Torrey. Fl. U.S. p. 424. 1824.

Azalea viscosa Linnaeus. Sp. Pl. 1:151. 1753.

Azalea viscosa palustris Marshall. Arbust. Amer. p. 16. 1785.

Rhododendron venustum Salisbury. Prodr. p. 287. 1796. (in part)

Azalea nitida Lindley. Bot. Reg. V, t. 435. 1819. (not Pursh)

Anthodendron viscosum (L.) Reichenbach in Moessler, Handb. Gewächsk. Ed. 2, 1:309. 1827. Swamp Honeysuckle. Swamp Azalea.

Deciduous shrubs to 3 or nearly 5 m tall, sometimes low, with irregularly whorled branches, stoloniferous. Twigs yellow-brown or gray-brown, hirsute or strigose. Bud glabrous, sometimes pubescent, usually brown with 8-12 broadly ovate scales rounded at apex and usually mucronate, ciliate; basal scales sometimes long-pointed. Leaves ovate, elliptic-obovate or oblong-lanceolate, acute or rounded, mucronulate, cuneate, 2-6 cm long, 0.5-2 cm broad, ciliate, glabrous; midrib slightly villous above, more or less strigose beneath. Petioles strigillose, 1-3 mm long. Flowers appearing after the leaves, white, rarely pink, no blotch, in clusters of 4-9, fragrant. Pedicels minutely pubescent, stipitate-glandular, 0.5-1 (-1.5) cm long. Calyx lobes semi-orbicular to ovate, setosely glandular-ciliate, about 1 mm long. Corolla funnelform, 1-5 cm dia; tube cylindric, somewhat dilated near the apex, finely villous, stipitate-glandular, about 1.5 cm long. Stamens 5, exserted, somewhat longer than lobes; filaments villous on lower two-thirds, white, 4-5.5 cm long; anthers yellow, 1-2 mm long. Style finely pubescent below middle, white, sometimes purple toward stigma, 4-6 cm long, exceeding stamens. Capsules oblong-ovoid, finely pubescent, glandular-setose, sometimes setose and eglandular, 1-2 cm long.

Common in swamps of Coastal Plain to higher mountains. Maine to Florida; west to Ohio, mountains of Pennsylvania to North Carolina, Tennessee; Mississippi, Arkansas, Louisiana, southeast Texas. April to June.

25. *Rhododendron serrulatum* (Small) Millais. Rhododendrons. p. 241. 1917.

Azalea viscosa Hooker. Comp. Bot. Mag. 1:100. 1835. (Not Linnaeus)

Rhododendron viscosum Chapman. Fl. S. U.S. p. 265. 1865. (not Torrey)

Azalea serrulata Small. Fl. S.E.U.S. p. 883. 1903. *Rhododendron viscosum* var. *serrulatum* (Small)

Ahles. Jour. Elisha Mitchell Sci. Soc. 80:173. 1964.

Hammocksweet Azalea.

Deciduous tall shrubs or small trees to 7 m tall with irregularly whorled branches and radiating white rhizomatoid root systems. Twigs bright red-brown, copiously strigose, finely villous. Buds glabrous or sometimes gray-pubescent with 15-20 ovate, mucronate or mucronate-aristate scales usually light yellow-brown with a sharply marked dark brown band along the white-ciliate margin. Leaves elliptic, obovate or obovate-oblong, rarely oblanceolate, 4-8 cm long, 1.5-3.8 cm broad, acute, rarely obtuse, mucronulate, cuneate at base, serrulate-ciliate margins, glabrous above and beneath, midribs sparingly short-villous above and strigose beneath. Petioles strigose, 1-4 mm long. Flowers expanding after the leaves and after winter buds are partially formed, white, in clusters of 6-10, no blotch, very fragrant clove-pink scent. Pedicels minutely pubescent, stipitate-glandular, 1-2 cm long. Calyx lobes semi-orbicular to ovate, long glandular-ciliate, to 1 mm long. Corolla funnelform, 2-3 cm dia; tube cylindric, slender, 2.5-3.5 cm long, 2 mm wide, slightly dilated at apex, copiously stipitate-glandular, sparingly villous; lobes ovate, lanceolate, acuminate, 1-1.5 cm long. Stamens 5, exserted about 1½ times tube length; filaments yellow, lower two-thirds villous; anthers ochraceous, oblong, 2-2.5 mm long. Style considerably exceeding stamens, slightly short-pubescent near base or glabrous, purple above, 4.5-6 cm long. Capsules ovoid-oblong, minutely villous, densely glandular-setose, 1-1.5 cm long.

Wet woods, Coastal Plain of Virginia, North and South Carolina, Georgia, Florida westward to Louisiana. June to early August.

26. *Rhododendron arborecens* (Pursh) Torr. Fl. U.S. p. 425. 1824.

Azalea arborecens Pursh. Fl. Am. Sept. p. 152. 1814.

Azalea verticillata Carr. Cat. Trees & Shrubs Bartram's Bot. Gard. p. 11. 1814.

Azalea arborea Bartram ex Pursh. Fl. Am. Sept. p. 152. 1814. (as synonym)

Azalea fragrans Rafinesque. Ann. Nat. p. 12. 1820. (not Adams)

Smooth Azalea. Sweet Azalea.

Deciduous tall shrubs or small trees to 6 m tall, not observed to be stoloniferous. Twigs yellow to light gray-brown, glabrous. Buds glabrous; scales light brown, ovate, ciliate, with rounded base, mucronulate apex. Leaves oblanceolate, bright green, ciliate, glabrous except for midribs, sparingly short-villous above and sparingly strigose beneath. Petioles glabrous, 3-8 mm long. Flowers expanding after leaves have unfolded, white to pink, no blotch on lobes, in clusters of 3-8, very fragrant. Pedicels red stipitate-glandular, 0.5 cm long. Calyx lobes ovate to linear-oblong, glandular-ciliate, 3-6 mm long. Corolla funnelform, 3-4.5 cm dia; tube 2-3 cm long, sparingly red stipitate-glandular,

slightly dilated at apex; lobes ovate-oblong, acuminate, 1.5-2 cm long. Stamens 5, exerted, about twice as long as tube; filaments purple above, pubescent below the middle; anthers 2-3 mm long, ochraceous. Style as long or longer than stamens, purple above, glabrous. Capsules oblong-ovoid, 0.5-2 cm long, densely glandular-hispid.

Banks of mountain streams, rarely on the borders of swamps. Appalachian Mountains, Pennsylvania to Georgia, Kentucky, Alabama. Late June, early July.

27. *Rhododendron prunifolium* (Small) Millais.
Rhododendrons, p. 230, 1917.

Azalea prunifolia Small. Fl. S. E. U. S., Ed. 2 p. 1356, 1913.

Plumleaf Azalea.

Deciduous shrubs to small trees over 5 m tall with irregularly whorled branches, often stoloniferous. Twigs glabrous, dark purple-red. Buds glabrous, orange to red brown, with broadly ovate, rounded, mucronulate, sometimes nearly aristate, ciliate scales 1-1.25 cm long. Leaves elliptic, sometimes obovate to oblong, acute or short acuminate, mucronulate, cuneate, 3-10 (-13.5) cm long, 1.5-4 cm broad, ciliate, glabrous above, very sparingly strigillose beneath, midribs slightly villous above and sparingly strigose beneath. Petioles glabrous or rarely sparingly strigose, 3-6 mm long. Flowers opening after leaves have expanded, in 4-5-flowered clusters, crimson, no blotch on lobes, not fragrant. Pedicels hirsute, 5-7 mm long. Calyx lobes semi-orbicular to ovate, glabrous, long-ciliate, 1-1.5 mm long. Corolla funnelliform; tube gradually widened above middle, 2-2.5 cm long, glabrous, sparingly hirsute or sparingly stipitate-glandular; lobes broadly ovate, abruptly acuminate, 1.5 cm long, 1-1.5 cm broad, more or less finely villous, sometimes slightly glandular-pilose. Stamens 5, much exerted, nearly 3 times tube length, 5-6.5 cm long; filaments yellow, villous on and below the middle; anthers ochraceous to yellow, 2-3 mm long. Style to 8 cm long, much exceeding stamens, glabrous, purple above, Capsules ovoid-oblong, strigose, finely puberulous, 2 cm long.

Shady ravines on stream banks. Southwestern Georgia, eastern Alabama. June-September.

Putative Hybrids and Species Transferred to Other Genera

Rhododendron fastigifolium (Lemmon) Hume.

Azaleas, Kinds and Culture, p. 28, 1948.

Azalea fastigifolia Lemmon. Bartonia 19:15, 1938.

Rhododendron furbishii (Lemmon & McKay)

Hume. Azaleas, Kinds and Culture, p. 28, 1948.

Azalea furbishii Lemmon & McKay. Bartonia 21:5-6, 1940.

These two taxa are putative hybrids described from areas known to have hybrid swarms of *Rhododendron*. Leach (1959) reported that in the crosses he made with *R. bakeri* and *R. arborescens* in an effort to duplicate "*R. furbishii*", resulting hybrids were almost

identical with those described by Lemmon. He also found that plants grown from seeds resulting from self-pollination of wild "*R. furbishii*", proved to be a segregating population with characteristics of *R. Bakeri* and *R. arborescens*. A similar situation obtains for *R. fastigifolium*, although the crosses have not been reported. Lee (1965) says "Material described under *fastigifolium*, with smaller red flowers and orange-yellow blotch, probably falls within the *speciosum-canescens* complex. Of the thirteen plants of *fastigifolium* originally discovered and transplanted, only a few are apparently still in cultivation." These taxa should be regarded as hybrids with the names *R. × furbishii* and *R. × fastigifolium*.

Rhodothamnus leachianus (Henderson) Copeland.
Amer. Midl. Nat. 30:565, 1943.

Rhododendron leachianum Henderson. Rhodora 33:205, 1931.

Kalmiopsis leachiana (Henderson) Rehder. Jour. Arnold Arb. 13:31-32, 1932.

Rehder considered this taxon to have enough characters different from *Rhododendron* that he placed it in a new genus, *Kalmiopsis*. However, Copeland found that *Kalmiopsis* was sufficiently like *Rhodothamnus* that it should no longer be maintained as a separate genus. Therefore, he merged it with *Rhodothamnus*, which has nomenclatural priority.

Acknowledgements

The use of facilities of and/or loans of specimens from The Academy of Natural Sciences, Philadelphia; Arizona State University; Auburn University; Florida State University; George Mason University; Longwood College; Lynchburg College; The Morris Arboretum; Mountain Lake Biological Station; The National Arboretum; Oklahoma State University; Old Dominion University; Oregon State University; Southern Methodist University; University of Georgia; University of Missouri-Columbia; University of North Carolina; University of Richmond; Vanderbilt University; Virginia Commonwealth University; Virginia Polytechnic Institute and State University; West Virginia University; and The College of William and Mary is acknowledged with thanks. Funding from the Flora Committee of the Virginia Academy of Science for collecting trips is greatly appreciated. Living plants representing most of the species that were collected and planted on the grounds of the Henry Foundation for Botanical Research by Mary G. Henry were studied. We also wish to thank Duncan Porter and Leonard Uttal for the suggestions for and comments on the manuscript.

Literature Cited

- Cronquist, A. 1968. The evolution and classification of flowering plants. 396 pp. Houghton Mifflin. Boston.
Duncan, W. H., and R. M. Pullen. 1962. Lepidote rhododendrons of the southeastern United States. Brittonia 14:290-298.

- Funk, Vieki A., and Marian J. Fuller. 1978. A floristic survey of the seeps of Calloway County, Kentucky. *Castanea* 43:162-172. 1978.
- Hitchcock, C. L., A. Cronquist, M. Ownbey, and J. W. Thompson. 1969. *Flora of the Pacific Northwest*. 730 pp. Univ. Washington Press. Seattle.
- Hulten, E. 1968. *Flora of Alaska and Neighboring Territories*. 1008 pp. Stanford University Press. Stanford.
- Leach, David G. 1959. The re-creation of a species. *Gard. Jour. N.Y. Bot. Gard.* 9:3-4.
- _____. 1961. *Rhododendrons of the World*. 544 pp. Charles Scribner's Sons. New York.
- Lee, F. P. 1965. *The azalea book*. Ed. 2. 435 pp. Van Nostrand. Princeton, NJ.
- Linnaeus, C. 1754. *Genera plantarum*. Ed. 5.
- Munz, P. A. 1963. *California Flora*. 1681 pp. University of California Press, Berkeley.
- Peck, Morton E. 1961. *Manual of the higher plants of Oregon*. Ed. 2. 962 pp. Oregon State Univ. Press., Portland.
- Read, R. H., and C. J. Wrzesinski. 1978. *Rhododendron lapponicum* in Wisconsin. *Quart. Bull. Amer. Rhododendron Soc.* 32:138-149.
- Rehder, A. 1927. *Manual of cultivated trees and shrubs*. 930 pp. Macmillan, New York.
- Roane, Martha K. 1975. *Rhododendrons native to Virginia*. *Va. Jour. Sci.* 26:6-12.
- Rydberg, P. A. 1922. *Flora of the Rocky Mountains and adjacent plains*. 1143 pp. Hafner Pub. Co. New York. Reprint.
- Shishkin, B. K., and E. G. Bobrov, Ed. 1967. *Flora of the USSR*. XVIII. Metachlamydeae. Trans. from Russian by Israel Program for Scientific Translation. 600 pp. Jerusalem.
- Small, J. K. 1914. *Ericaceae*. *N. Amer. Flora* 29(1):33-102.
- _____. 1933. *Manual of the Southeastern Flora*. 1154 pp. New York.
- Solymosy, S. L. 1976. A treatise on native azaleas. *Bull. Louisiana Soc. Hort. Res.* 10(2):7-74.
- Viereck, Leslie A., and Elbert L. Little. 1972. *Alaska trees and shrubs*. USDA Forest Service. Agric. Handb. 410. 265 pp. Washington, DC.
- Wilson, E. H., and A. Rehder. 1921. A monograph of *Azalea: Rhododendron* subgenus *Anthodendron*. *Arnold Arb. Publ.* 9. 219 pp. Harvard University Press. Cambridge.
- Wood, Carroll E. 1961. The genera of *Ericaceae* in the southeastern United States. *Journ. Arnold Arb.* 42:10-80.

NOTES

5.73
21
V5X

VIRGINIA JOURNAL OF SCIENCE

VOL. 32, NO. 3
FALL 1981



OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware
Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer
Route 2, Box 637
Lancaster, Va. 22503

©Copyright, 1981 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P.O. Box 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia and additional entry at Harrisonburg, Virginia 22801. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1982: \$20.00 per year, U.S.A.; \$30.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$7.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send address changes to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper (8½ × 11 inches). Margins should be not less than 1¼ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and affiliation, and proposed running title, all appear-

ing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first and last page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. *Metamorphic Textures*. Pergamon Press, New York. 350 pp.

Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians, Part III. Vertebrates* (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 32

No. 3

Fall 1981

TABLE OF CONTENTS

COMMITTEE REPORTS

Awards	64
Constitution and Bylaws	66
Finance and Endowment	66
Flora	66
Membership	66
Research	68
Science Advisory	68
Virginia Junior Academy of Science	69
Botany Section	69
Geology Section	69
Editor's Report	69

ABSTRACTS OF PAPERS, *Fifty-Ninth Annual Meeting of the Virginia Academy of Science, May 12-15, 1981, Old Dominion University, Norfolk.*

Aeronautics and Aerospace Science	70
Agricultural Sciences	73
Astronomy, Mathematics, and Physics	82
Biology	86
Botany	101
Chemistry	107
Education	114
Engineering	117
Environmental Science	120
Geology	126
Materials Science	130
Medical Sciences	133
Microbiology	140
Psychology	144
Statistics	147

Virginia Academy of Science Fifty-Ninth Annual Meeting, Old Dominion University May 12-15, 1981

The Awards Committee

Upon recommendation by the Awards Committee and by election by Council, four people have been designated as Fellows in the Virginia Academy of Science because of their contribution to science in one or more of the following ways: (a) outstanding scientific research, (b) inspirational teaching of science, (c) significant leadership in the Academy.

Let me pause at this point and remind everybody that at least three nominations or endorsements for each 1982 Fellow candidate must be submitted in writing to the Awards Committee or the Executive Secretary before June 1 of this year.

The vita of each person being named a Fellow this year shows extensive scientific achievements, but I shall cite only a few.

The first person has been an outstanding high school teacher for many years in Wise and Tazewell Counties and the city of Williamsburg. He has served as Science Supervisor in Old Norfolk County, City of Portsmouth and City of Fredericksburg, as Assistant Superintendent of Fredericksburg City Schools and as a consultant to the U.S. State Department in Germany.

A native of Southwest Virginia, he holds the B.A. degree from Emory and Henry College and the M.S. degree from George Peabody College. He either has done graduate work or has teaching experience at eight different universities. He has written five books for high school science students and is the author of numerous science articles and pamphlets in the field of education, marine biology and folklore.

He is the recipient of the Distinguished Science Award from Emory and Henry College and from the Virginia Junior Academy of Science. Last, but not least in any sense, he was the first Director of the Virginia Junior Academy of Science.

For these achievements and contributions, the Virginia Academy of Science names as a Fellow of the Academy, Mr. **Hubert J. Davis**.

The second person chosen to be a Fellow is truly a man of distinction and a loyal supporter of the Academy for many years. He is a renowned physicist and university educator, earning both the B.A. and Ph.D. degrees at the University of Virginia. As a student at the University, he was elected to Phi Beta Kappa, Omicron Delta Kappa and the University's own leadership society, the Raven Society.

After 25 years as a teacher and administrator at the University of Virginia, he was named the fifth president of the University in 1974. He was awarded the

Thomas Jefferson Award in 1966, perhaps the most coveted award bestowed of the University. With all the demands and responsibilities of a university president, he still finds time for the Academy, the latest as a panelist on the Negus symposium at last year's Annual Meeting. He also was a co-recipient of the J. Shelton Horsley Research Award in 1953.

In recognition of his scientific contributions, his educational leadership in the state of Virginia and his loyal support of the Virginia Academy of Science, the Academy hereby names as a Fellow, Dr. **Frank L. Hereford, Jr.**

The third person elected as a Fellow is a botanist by training. After earning the B.S. degree at Stetson University, he began his career teaching biology and natural science in the public schools in Florida and Maryland. For the past 17 years he has been with the U.S. National Arboretum in Washington, D.C. as a herbarium curator. He is a leading authority on trees and wildflowers having traveled and written extensively in his field. He is often called on by the Shenandoah National Park and local institutions to counsel and instruct in many botanical activities.

Perhaps his greatest recognition has come from the role he played in the research and rediscovery of *Betula ulmer* in Southwest Virginia, an unusual birch tree thought to be extinct. For this, he was named a co-recipient of the J. Shelton Horsley Research Award in 1976. He has also chaired the Flora Committee and served on the Academy Council.

For these scientific achievements and Academy support, the Academy hereby names as a Fellow, Mr. **Peter M. Mazzeo**.

The fourth person being named a Fellow in the Academy earned the B.S. degree from Lynchburg College and the Ph.D. degree from the University of Virginia. He joined the University of Richmond faculty in 1952 and has served very effectively as chairman of its Department of Biology since 1965.

Perhaps his greatest recognition has been his contribution to and leadership role in the Academy, always in a rather quiet but effective manner. He has served on the Academy Council for many years as a representative of the Biology section, as chairman of the Membership Committee and currently, very ably, as Secretary of the Academy.

For this true dedication to the Academy and his academic science leadership role, the Academy names as a Fellow, Dr. **Warrick R. West**.

Three people have had conferred upon them Honorary Life Memberships in the Virginia Academy

of Science in recognition of their long and distinguished service to science. The first person is a graduate of William and Mary where he was elected to Pi Kappa Alpha, Alpha Kappa Psi and Phi Kappa Phi. He enjoyed a long and illustrious career with the American Tobacco Company wherein he progressed from Chemist, to Division Head, to Assistant Director of Research, to Assistant to Vice President for Research and Development, and finally to Director of Technical Information and Coordinator of Community Relations.

He served as Business Manager of the Virginia Journal of Science from 1967 to 1970, and has been a sustaining member of the Academy for many years. He is also a Fellow in the Academy and a recipient of the Virginia Junior Academy of Science Distinguished Service Award.

Perhaps you know him best as our Executive Secretary-Treasurer for the past ten years. In this capacity he has earned the undying gratitude of all of us in his efficient administration of the business of the Academy. It is only fitting that we show our appreciation for this dedicated service by naming as an Honorary Life Member of the Virginia Academy of Science, **Mr. Blanton M. Bruner.**

The second person holds three degrees from the University of Florida, the B.S., M.S. and Ph.D. in Biology. He served on the Biology faculty of both Florida and the University of Virginia, and at the latter, served as Director of the Mountain Lake Biological Station for six years. For the past 19 years he has been Head Curator and Senior Zoologist of the Smithsonian Institution's Department of Invertebrate Zoology at Washington, D.C. He is a member of some fifteen professional and honorary societies, serving as president of the American Microscopical Society and of the Association of Southeastern Biologists.

His scientific foreign travel has been very extensive, and he is the author of some 150 scientific articles and books.

His Virginia Academy of Science involvement is also quite envious. As an Academy Member since 1946, including sustaining membership the past 10 years, he served as Technical Editor and Editor of the Virginia Journal of Science for 7 years, as a member of Council for 14 years and as President in 1961-62. He is a Fellow in the Academy, and is a recipient of both the J. Shelton Horsley Research Award and the Ivey F. Lewis Distinguished Service Award.

For this long and distinguished service to science and the Academy, an Honorary Life Membership in the Academy is hereby bestowed on Dr. **Horton H. Hobbs, Jr.**

The third Honorary Life Member recipient is also a scientist of equal distinction. He received the B.A. degree from Bridgewater College, and the M.S. and

Ph.D. degrees from the University of Virginia. His professional experience as a horticulturist—genetics as a discipline—included the staffs of Bridgewater College, Harvard University, Texas A&M University, University of Virginia, Virginia Tech and Wake Forest University where he retired last year as Professor Emeritus.

He has held, or is holding memberships in over twenty scientific societies and organizations, he has traveled abroad to many countries on scientific missions and he has over 100 technical articles to his credit. He is listed in 17 types of Who's Who.

His Virginia Academy of Science involvement and achievements includes membership for the past 52 years, member of many committees, a Fellow, a recipient of both the J. Shelton Horsley Research Award, and the Ivey F. Lewis Distinguished Service Award and President of the Academy in 1955.

It is a privilege to name as an Honorary Life Member of the Academy, Dr. **Walter S. Flory, Jr.**

Ivey F. Lewis Distinguished Service Award

The Ivey F. Lewis Distinguished Service Award is the highest honor the Academy can bestow. It is presented periodically for significant contributions toward the activities of the Virginia Academy of Science. For only the second time in the 25-year history of this award the recipient for 1981 is a company rather than an individual. The 1981 recipient of the Ivey F. Lewis Distinguished Service Award is Philip Morris, and Company.

Aside from being a business member of the Academy for many years, the most significant support has been to the Junior Academy program. The support, primarily, has been in the form of annual grants over the past 20 years for student paper awards and Philip Morris personnel attending the Annual Meeting to present the awards. At present the grant is \$2200 plus sponsoring a new VJAS fund-raising brochure whereby Philip Morris will provide the services of its art development and print 3,000 copies of the 8-page brochure.

Several of the Philip Morris personnel should be cited for the administration of the grants and for attending the annual Junior Academy meetings to make the student awards. They are Dr. Helmut R. Wakeham, Director of Research and a 1980 VAS Fellow recipient; Dr. Robert B. Seligman, Vice President of the Division of Research and Development; Mr. Robert W. Norris, Manager of Corporate Relations; Mr. Ralph E. Antell, Manager of Administrative Services; and Mr. Bernie J. Kosakowski, Manager of Administrative Services, succeeding Mr. Antell.

The Virginia Academy of Science bestows the 1981 Distinguished Service Award upon **Philip Morris, Inc.**

E. L. Wiseman, Chairman

Constitution and Bylaws Committee

Proposed Bylaw changes must be distributed to the membership or published in the *Virginia Journal of Science* at least 30 days prior to action by Council. Adoption requires an affirmative vote of a majority of the total membership of Council.

Council approved the following at the May 14 meeting of the 1980-81 Council:

Amend; Article I, Types of Membership and Dues, Section 2, Paragraphs 1 thru 4 to read as follows;

- (1) Regular members shall pay annual dues *fifteen dollars (\$15.00)*.
- (2) Student members shall pay annual dues *of five dollars (\$5.00)*.
- (3) Contributing members shall be members who elect to pay annual dues of *twenty dollars (\$20.00)*.
- (4) Sustaining members shall be individuals and institutions who elect to pay annual dues of *thirty dollars (\$30.00)* or more.

To be effective for fiscal year beginning January 1, 1982 and thereafter until changed.

J. W. Midyette, Jr., Chairman

Finance and Endowment Committee

a) From the report presented here, prepared by the committee and submitted to Council in Nov. 1980 by A. W. Burke, a trend of dwindling reserves in the General Fund is apparent. At least two steps have been taken, or proposed to reverse this trend are now in effect:

1. Reduced outlay for support of Va. Journal of Science, following guidelines established by Council in 1980.
2. Increased dues structure, with the resulting increased income to be earmarked to restore the General Fund.

b) Membership statistics for 1980 show little change over the past three years. This seems a fertile area for growth.

K. P. Bovard, Chairman

Flora Committee

The Flora Committee met on May 14, 1981 at Old Dominion University. Taxonomic work on various plant groups was discussed. A paper on Phrymaceae and Plantaginaceae has been published and one on *Rhododendron* is in press. Work on the milkweeds (Asclepiadaceae) and *Sisyrinchium* is in progress. Study of certain members of the Heath Family (Ericaceae) is to be initiated.

Funds for publication of the brochure on careers and avocations in botany are slowly accumulating and amount to 29% of the \$650 needed.

The priority listing of threatened and/or endangered plants has not yet been compiled. Persons working for the Nature Conservancy are working on such a listing or may have already compiled it. The status of this listing is to be discussed at the next Flora Committee meeting.

Peter Mazzeo reported that only about half of the original number of trees of *Betula uber* are extant in the type location.

The project of compiling a bibliography of Virginia's floristically related literature was discussed. The opportunity to revive this project is presented to the new chairman of The Flora Committee.

Representation of The Flora Committee and The Botany Section at the fall Science Teacher's Conference was discussed. If it is held in Roanoke, Dr. Martha K. Roane will represent the botanists. Contact with Mr. Exline regarding the conference will be made by the new chairman of The Flora Committee.

Jeffersonia, the botanists' newsletter, is financially stable. Volume 12(1) has been issued. Martha Roane will continue editing it through the completion of Volume 12.

The committee designated \$100 for work on the Santalaceae and Orobanchaceae by Lytton Musselman and \$150 for work on threatened and/or endangered plants by Donna Ware. There was a discussion of the purpose of the research funds. The consensus was that these funds are to be used only for floristic research.

The possibility that the fall meeting of The Flora Committee be held in 2 sections, an eastern and a western, was discussed. Also the possibility of field trips was brought up. Resolution of these suggestions is turned over to the new chairman of The Flora Committee.

Martha K. Roane, Chairman

Membership Committee

The Membership Committee performed its tasks in much the same way as has been done over the past few years. However, it is not very gratifying to report that membership dropped to 1,494 as of 1/1/81 from 1,530 in 1/1/80. Sixty-seven new members have been added in the first four months of 1981.

Letters were sent to 276 people whose names appeared in VAS Virginia Scientist Program who were not members of the Academy. They were asked to join the VAS and enjoy the benefits of being a supporting member of the Academy.

Letters and brochures were sent to eighteen laboratories and consulting firms in the Washington, D.C. area asking them to participate in the Virginia Academy of Science.

Dr. Peter Trower of the Physics Section sent numerous brochures and invitations to prospective members. Perhaps we can determine the results of this mailing after this annual meeting.

Michael L. Bass, Ph.D., Chairman

Summary of Receipts and Disbursements — 1978-81

	Actual 1978	1979	Budget 1980		Budget 1981
Receipts					
Dues	\$16,950	\$18,200	\$18,100		\$18,400
Gifts (esp. VJAS)	5,417	5,327	7,200		5,000
Annual Meeting	9,164	6,666	6,900		6,400
Va. Journal of Sci.	4,014	2,855	1,650		4,020
Interest	1,802	2,676	1,800		1,500
Income/Trust	2,200	2,200	3,300		4,000
Other	674	417	---		---
Total:	<u>\$40,221</u>	<u>\$38,341</u>	<u>\$38,355</u>		<u>\$39,320</u>
Disbursements					
				Disbursements^a to 1981 Oct. 31	
Salaries & Benefits	3,105	3,385	3,850	2,979	3,900
General Expenses	3,372	3,593	3,020	3,268	3,900
Meeting Expenses	3,156	3,515	3,200	2,333	3,300
VJAS	10,802	9,524	11,535	7,797	10,000 ^b
Va. J. Sci.	18,088	21,774	11,650	14,871	14,020 ^c
Research & Horsley	2,429	2,600	3,350	3,143	3,800
Vist. Sci. Prog.		1,428	750	719	800
Flora Comm.	(300)	300	300	300	300
Contingency Fund		316	400	270	400
NEWSLETTER ^d	---	---	---		400
AAAS Rep./travel		304	300	453	400
	<u>962</u>				
Total:	<u>\$41,914</u>	<u>\$46,739</u>	<u>\$38,355</u>	<u>\$36,133</u>	<u>\$41,220</u>
Operating Deficit	1,693	8,398	---		1,900
General Fund	42,749	34,774		Est. 30,000	Est. 28,000

^aNotes to Financial Data: Actual disbursements to 1980 October 31 are itemized for reference use only. Anticipated and/or possible significant "year end" expenditures include: Journal +2,500; VJAS +2,500 — travel and printing; Salary and General +1,250, or Estimated \$7,250 to Dec. 31. This will project a deficit for 1980 of about \$5,000 (36G + 7G - 38G). This will project a further erosion of the General Fund to \$30,000.

^bThe proposed budget figure includes the \$5,000 direct subsidy, as requested by the VJAS Committee, and a VAS guarantee of \$5,000 direct subsidy, as requested by the VJAS Committee, and a VAS guarantee of \$5,000 for anticipated and reasonably expected gifts " earmarked " for VJAS activities (e.g. Philip Morris = 2,100, ATC = 400, & other reasonable = 2,500). Any funds gifts raised by the VJAS, over and above these guaranteed amounts, would accrue exclusively to benefit to VJAS.

^cThe proposed budget figure includes the "ceiling" placed by 1980 council of \$10,000 plus the estimated revenues of \$4,020 by the Journal.

^dNew item, NEWSLETTER.

Virginia Academy of Science
MEMBERSHIP STATISTICS, 1978-80

	1978	1979	1980
Membership Begin. Year	1,360	1,466	1,530
Add	224	240	141
Resign & Died	-26	-49	-55
Dropped—Non Pay.	-92	-127	-122
End of Year	1,466	1,530	1,494
Regular	1,165	1,197	1,165
Contributing	100	100	95
Sustaining	53	57	58
Student	113	139	138
Life	16	20	19
Business	19	17	19

Research Committee

R. C. Bates assumed the Chairmanship of the Research Committee on January 1, 1981. Since January 1st, 6 proposals have been received and reviewed. Four research grants were awarded for a total of \$1,381. One proposal was returned for a budget revision and one proposal was not funded.

Six research papers were submitted in competition for the 1981 J. Shelton Horsley Award. The papers were again kindly reviewed by the Sigma Xi Chapter of West Virginia University. The author of this paper will receive a check for \$500 and a certificate.

The review process for research proposals is presently undergoing modification and revision. It is anticipated in the face of an increasing number of proposals that we will not be able to fund (with our limited funds) all worthy requests in the future. Therefore, the committee is considering establishing two deadlines (April 15th and October 15th each year) for receiving applications for research funds. This would allow us to select the most outstanding projects for funding.

Preparations are being made for advertisement and distribution of funds, when they become available, from the Horsley Cancer Research Fund. Dr. Banks is involved in developing guidelines for this new activity of the Research Committee.

Members of VAS, who seek financial support of their research in the form of small grants (viz., less than \$500), should contact R. C. Bates for application forms and further information at the Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061; Phone: 703-961-5702.

Robert C. Bates, Chairman

Science Advisory Committee

I am happy to report to the Academy that after five years of persistent effort on the part of the Committee to Plan a Science Advisory System we have a very encouraging response in the form of a policy statement from Governor John N. Dalton. On May 27, 1980, pursuant to the report on the "State Science, Engineering and Technology Capacity in State Government" December 1978, Governor Dalton issued the following policy memorandum.

"It shall be the policy of the Commonwealth to apply as effectively as possible, scientific and technological information and expertise to the analysis of policy options and the resolution of major state problems.

Virginia is fortunate in having scientific and engineering expertise upon which to call. State agencies are presently utilizing many of these resources, but more effective and greater use of them is encouraged. Closer coordination between the State and its scientific community is necessary. To this end, the Governor's Science and Technology Advisor and Science and

Technology Advisory Committee shall be continued to improve communications between State agencies and the State's scientific community.

A continuing role within State government, however, is also necessary. The Department of Planning and Budget shall serve as the agency responsible for overseeing the implementation of this policy and for supporting the activities of the Governor's Science and Technology Advisor and the Science and Technology Advisory Committee. All agencies in the executive branch shall work with the Department in carrying out this responsibility.

In general, the Department shall develop and implement procedures for assuring more effective use of science and technology information within State government. More specifically, the Department shall:

- Advise the Secretaries and State agencies on the scientific and technological content of major issues.
- Maintain liaison and knowledge of scientific expertise within State agencies, the academics and private sectors, as well as with major federal research laboratories and agencies.
- Identify resources to aid in conducting professional policy analyses of issues with scientific and technological content and assist State personnel in utilizing such resources.
- Review policy analyses and legislative proposals for the scientific and technological content.
- Build upon the previously compiled resource inventory to identify resources for use by Agency and Secretarial personnel.

The Department shall also be responsible for re-evaluating, on a continuing basis, the effectiveness of the State's efforts to improve the utilization of scientific and technological information in its decision-making process. This evaluation should not only focus on the use of such information, but also focus on the means by which the State mobilizes the resources available to meet the objectives outlined in this memorandum."

The efforts of the Science Advisory Committee have been devoted to expanding the inventory of resource personnel in cooperation with the Department of Planning and Budget. Approximately 550 scientists and engineers have volunteered their services and the file is currently being cross-referenced and developed in a format which can be circulated to all state agencies.

The Chairman of the Science Advisory Committee, in response to an invitation from the Association of State Academies of Science, participated in a symposium entitled "Promoting Science at the Grass Roots Level—The Local Academy. A Successful State Government Liaison Program" at the AAAS meeting in Toronto, Canada, January 5, 1981. The progress report on the activities of the Virginia Academy received a very good response from participants.

Ertle Thompson, Chairman

Virginia Junior Academy of Science

The 1981 meeting had 54 clubs to register which includes 453 students, sponsors and teachers. From a total of 374 papers 203 were selected to be read. Very few failed to show. The VJAS committee performed their duties well so activities were successfully completed. The speaker, Dr. S. N. Postlethwait, Purdue University, was well received. His talk on "The Wonderful World of Plants" was a multi-image presentation. The awards program was held on May 14. All regular and special awards were given. New officers were elected. Thanks to the support and effort of Dallas Cocke and Philip Morris, Inc., a brochure to be used in fund raising efforts has been prepared and printed. This tool will be of considerable value to use to help the VJAS become more self-supporting.

R. Dean Decker, Director, VJAS

Botany Section

In an invitational session on "Current Vegetational Ecology Research in Virginia Forests" organized by Frank P. Day, Jr. and Terry L. Sharik, a number of very fine papers were presented. Other papers presented ranged in topics from phytoplankton studies to the flora of Antarctica. The paper sessions were interesting and well attended.

In the business session, new officers were elected. Items of business discussed were participation in the Science Teachers' Conference in the fall, the progress of the brochure on careers and avocations in botany and the status of Jeffersonia. The councilor reported on items of interest from The Academy council meeting on May 14, 1981.

Martha K. Roane

Geology Section

The Geology Section of the VAS had 26 papers scheduled for the 1981 Annual Meeting, held at Old Dominion University. The number of papers necessitated holding the meetings on two days; the Friday morning session included a mini-symposium on Virginia Piedmont geology. There were several excellent papers given by students. The competition for the annual award for best student paper was a tie and the award was shared by Karen Bice of the College of William and Mary and Robert R. Seal, II of VPI & SU; both are undergraduates. An additional award, one for the best paper on economic geology by a student, will be given in 1982. We are looking forward to another round of fine papers and discussions at the 1982 session, which is to be held in Blacksburg.

S. O. Bird, Secretary, 1981

Editor's Report

Though the Virginia Journal of Science is now back on schedule and being printed at half of its previous costs, the Publications Committee and Council have directed that the Editor and Business Manager move to have the Journal printed by photoreproduction of camera-ready copy (as is done with the abstracts of the Proceedings Issue), eliminating the cost of most typesetting. While the Editor feels obligated to publish all already accepted papers by set type, he expects to move entirely to the revised format by the end of the 1982 volume.

Because the Editor will be without office space from June until October while peeling asbestos insulation is removed from the Biology building at William and Mary, the Proceedings Issue of the Journal may be delayed.

Abstracts of Papers

Aerospace Science Aeronautics and

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

EFFECT OF BOUNDARY LAYER GROWTH ON THE THREE-DIMENSIONAL STABILITY OF TRANSONIC AND SUPERSONIC FLOWS. N. M. El-Hady*, Dept. of Mech. Engg. & Mechanics, ODU, Norfolk, Va. 23508

The method of multiple scales is used to describe a formally correct method based on the nonparallel linear stability theory, that examines the two- and three-dimensional stability of compressible boundary-layer flows. The method is applied to the supersonic flat plate boundary layer at Mach number 4.5. The theoretical growth rates are in good agreement with the experimental results of Kendall. The method is also applied to the infinite-span swept wing transonic boundary layer with suction to evaluate the effect of the nonparallel flow on the development of crossflow disturbances.

The work was supported by the NASA Langley Research Center, LFCAEO, Grant NSG1645.

GÖRTLER INSTABILITY IN COMPRESSIBLE BOUNDARY LAYER WITH SUCTION OR COOLING. N. M. El-Hady*, A. K. Verma*, Dept. of Mech. Engg. & Mechanics, ODU, Norfolk, Va. 23508

The instability of the laminar compressible boundary layer flow along a concave wall is investigated. A compressible linear stability theory is presented for the three-dimensional longitudinal type vortices in two-dimensional boundary layers with suction or cooling along the concave wall. The analysis includes the effect of the boundary layer growth, that is, the velocity component normal to the curved wall, as well as the streamwise variation of the meanflow quantities.

Compressibility reduces the growth rates and amplitude ratios of these vortices. This effect is evaluated for a range of Mach numbers from 0 to 5. The effect of wall cooling and suction of the boundary layer on the development of these vortices is investigated at Mach number 3. Cooling or suction seems to locally destabilize the boundary layer in terms of the critical Görtler number; however, it reduces the total streamwise growth of the vortices. An evaluation is presented for the effectiveness of cooling or suction in delaying transition caused by Görtler vortices.

This work was supported by the NASA Langley Research Center, LFCAEO, under Grant NSG 1645.

NITROGEN CONDENSATION-COMPARISON OF AIRFOIL EXPERIMENTS WITH HOMOGENEOUS NUCLEATION THEORY. R. M. Hall, P. B. Gooderum*, and E. H. Dotson*, NASA Langley Research Center, Hampton, Va 23665

Avoidance of condensation effects due to homogeneous nucleation (self-nucleation) of the test gas has long been a concern during the operation of most transonic and supersonic wind tunnels. Renewed interest in condensation has resulted from the development of cryogenic, transonic wind tunnels which use low temperature nitrogen gas as the test medium. Until recent airfoil experiments in the Langley 0.3-m Transonic Cryogenic Tunnel, however, very little data were available for comparisons between theory and experiment in the pressure and temperature regions of interest to cryogenic tunnels. The agreement between the new data and theory will be discussed and conclusions made.

CONTROL OF LARGE SPACE STRUCTURES: A CHALLENGE OF THE FUTURE. S. M. Joshi* Vigyan Research Associates, Inc., 28 Research Drive, Hampton, VA 23666 (presently with Old Dominion University Research Foundation, Norfolk, VA 23508.)

A number of potentially important, new space initiatives and missions require large space structures (LSS) with dimensions which range from one hundred to several thousands of meters. Example structures include very large microwave reflectors, microwave antennas, platforms, solar energy collectors, solar sails and telescopes. Such missions will be economically feasible because of the availability of the space Shuttle. Control systems design for LSS is a complex and challenging problem because of high flexibility of LSS. Pointing requirements dictate that the desired closed-loop bandwidth be higher than modal frequencies of some of the structural bending modes. In this paper, the problems involved in attitude and shape control of LSS are discussed, and some methods of designing stable, robust controllers for LSS are presented. (Supported by NASA Contract NAS1-16126)

VISCOUS-CORE ANALYSIS AND INVISCID PREDICTION OF VORTEX-CORES OF LEADING AND TRAILING EDGE SEPARATIONS OF DELTA WINGS*.
C. A. Kandil and B. Balakrishnan*, Dept. of Mech. Engrg. and Mecs., Old Dominion Univ., Norfolk, Va. 23508

The separated free-shear layers from the leading edges of a delta wing roll up spirally into two counter rotating vortex cores. These vortex cores (primary vortex cores) highly influence the aerodynamic characteristics of the wing over a wide range of angles of attack. In this paper, we present a realistic viscous-inviscid model for the wing and its vortex cores to predict the effect of the wing angle of attack and its aspect ratio on the vortex-core size. The final goal of this research work is to develop computer codes capable of predicting the wing aerodynamic characteristics, particularly near the angle of stall for steady and unsteady flows.

Viscous modeling is limited to the core flow only while inviscid modeling is adopted for the rest of flow region. Boundary-layer-like approximations are applied to the core flow and the resulting equations are solved by a finite-difference technique. Boundary conditions for the core model are obtained from the solution of the inviscid model. The inviscid model is solved by the Modified Nonlinear-Discrete method developed earlier by the senior author. Several numerical examples are presented for the steady flow about a delta wing of aspect ratio of unity.

*This work is supported by NADC, Warminster, Pa. under contract No. N62269-80-65-02024, Mr. M. Walters and Dr. K. T. Yen are tech. monitors.

ANALYTICAL STUDY OF HIGHLY SWEEP WINGS WITH LEADING-EDGE VORTEX FLAPS AND STRAKES. C. S. REDDY*, Mech. Engrg. and Mechanics Dept., Old Dominion Univ., Norfolk, Va. 23508

The effect of leading-edge vortex flap deflection on the aerodynamic performance of a 74° delta wing is analytically studied using the free vortex sheet method developed by Boeing Aircraft Company under a contract with NASA Langley Res. Ctr. The longitudinal aerodynamic characteristics are computed and the vortex sheet shapes determined for various flap-up and flap-down situations. It is found that the effect of the vortex flap deflection is more dominant on the drag and the lift-to-drag characteristic than on the lift and pitching moment. By proper deflection of the flap, the drag can be increased or decreased, and this can be advantageously utilized during various flight regimes.

Also, the influence of the leading-edge sweep angles on the aerodynamic characteristics of a strake wing model is investigated employing the same method. The basic model considered here is a double arrow wing which has an 80° inboard sweep, 65° outboard sweep, pointed tip and 30° trailing-edge sweep. It is observed that lift and drag increase with increase in inboard and outboard sweeps. However, the lift-to-drag ratio is little effected by the changes in the sweep angles. The span-wise pressure distributions in the aft region of the wing are considerably influenced by the inboard sweep angle, whereas the outboard sweep angle appears to have no discernable effect on pressures in the wing forward region. (Aided by NASA grant NSG-1561)

SOME TESTING AND ANALYSIS TECHNIQUES APPLICABLE TO THE AERODYNAMIC ASSESSMENT OF AIRPLANES AND MISSILES, M. Leroy Spearman, Aerospace Technologist, Aeronautical Systems Division, NASA Langley Research Center, Hampton, 23665.

Some test and analysis techniques, both analytical and experimental, can be used to: (1) approach optimum configuration arrangements to achieve certain desired aerodynamic characteristics, and (2) assess the aerodynamic performance bounds for a specific configuration. The techniques include methods for both airplane and missile configurations to show trade studies that can be made and indicate the test data required. For example, when the dynamic pressure limits are known, nomographs can be developed to define the operational altitude and Mach number bounds for a configuration. When the maximum usable lift is known, nomographs can be used to determine the instantaneous normal acceleration as a function of altitude, wing-loading, and Mach number. The effect of stability level (or center of gravity location) can also be included. Among the trades that can be shown are the effects on turn radius of speed and normal acceleration from which some implications on air-to-air combat, and on missile-intercept capability, are apparent. Some test techniques, such as remote activation of control surfaces during the test run to trim the pitch, roll and yaw, provide savings in time and cost and the data more accurately simulates true flight conditions.

TWO-DIMENSIONAL TRANSVERSE INJECTION INTO A SUPERSONIC MAINSTREAM. G. D. Kraemer*, Graduate Research Assoc., Dept. of Mech. Eng. and Mech., O.D.U., Norfolk, Va., R. C. Rogers*, Aerospace Engineer, NASA-Langley Research Center, Hampton, Va., and S. N. Tiwari, Eminent Professor, Dept. of Mech. Eng. and Mech., O.D.U. Norfolk, Va.

An experimental investigation of the interaction of a sonic slot jet injected transversely into a Mach 2.9 air mainstream is being conducted. This investigation will examine aerodynamic features, such as the extent and nature of separated regions near the jet and wall static pressure distributions. Jet mixing downstream of the jet will be investigated by instream pitot pressure, static pressure, and gas composition profiles. Surface gas composition distributions in the separated regions near the jet will be obtained from surface taps. A prime objective of these tests is to provide data pertaining to the jet mixing and interaction suitable for comparison with an existing two-dimensional theoretical solution. The scope of the present test program is to inject nitrogen or helium gas at pressures of 5, 10, and 20 times the mainstream static pressure from two injector gap widths. The downstream flow field will be mapped by obtaining static pressure, pitot pressure, and gas composition profiles at three downstream stations. An overview of the experiment and typical results will be presented.

A SIMPLIFIED VORTEX LATTICE MODEL FOR POTENTIAL FLOW PAST A FUSELAGE. Jin-Yea Shu*, and John M. Kuhlman, Dept. of Mechanical Engineering and Mechanics, ODU, Norfolk, VA 23508

The Vortex Lattice representation of lifting surfaces and non-lifting bodies, for prediction of aerodynamic performance, has been well developed over the past thirty years. However, because the geometry of the general fuselage is fairly complicated, much computing time and computer memory is needed to obtain the circulation strength solution using the full influence matrix. In view of this, through the present technique of transformation to approximate the actual body by a bounding rectangular box, the solution is obtained easily with less computer cost, with little sacrifice in accuracy for slender fuselages. Actual boundary conditions are transformed to the rectangular box through use of slender body theory, using a concept previously applied for transonic wing-bodies. The development of the theory will be summarized, and results will be presented for an axisymmetric fuselage at zero angle of attack. (Aided by NASA grant NSG 1357.)

FIBER OPTIC DATA DISTRIBUTION CONCEPT FOR CIVIL AIRCRAFT. J. L. Spencer*, H. D. Hendricks*, and C. J. Magee*. NASA Langley Research Center, Hampton, Va. 23665

Langley Research Center, as part of its controls and guidance program, is developing technologies to make civil aircraft of the 1990-2000 period more efficient and safer. One of these technologies involves the use of fiber optics on board the aircraft for reliable distribution of data between the flight crucial computing system and the sensors and actuators. This presentation describes a fiber optic wavelength multiplexing concept for the data distribution which is more reliable and lower in weight than conventional wire systems. The system concept will be discussed, hardware components (semiconductor lasers, optical fibers, optical multiplexers, optical demultiplexers, and PIN detectors) will be described and the system benefits detailed. Data will be presented on the performance of a four wavelength system.

ANALYSIS OF AEROTHERMODYNAMIC ENVIRONMENT OF A TITAN AEROCAPTURE VEHICLE. S.N. Tiwari and H. Chow*, Dept. of Mechanical Engineering and Mechanics, Old Dominion University, Norfolk, Virginia 23508, and J.W. Moss, NASA Langley Research Center, Hampton, VA 23665

The extent of convective and radiative heating of a Titan entry body is investigated. The flow in the shock layer is considered to be axisymmetric, steady, laminar as well as turbulent, viscous, and in chemical equilibrium. The implicit finite difference technique is used to solve the viscous shock-layer equations for a 45-degree sphere cone at zero angle of attack. Different compositions for the Titan's $N_2 - CH_4$ atmosphere were assumed and results were obtained for the entry conditions specified by OPL. The results show that the amount of CN concentration in the shock layer gas determines the extent of radiative heating to the body. Radiative heating downstream of the stagnation point increases due to an increase in CN concentration. It is found that both the convective and radiative heating increases significantly as the N_2 concentration increases.

ELASTIC DEFORMATION EFFECTS ON AERODYNAMIC LOADS.

Judith J. Watson.* NASA Langley Research Center, Hampton, Va. 23665

A series of wind tunnel tests has been conducted in the Langley Transonic Dynamics Tunnel to investigate the effects of oscillating control surfaces on unsteady aerodynamics. The tests were conducted on a high aspect-ratio, force/pressure, supercritical wing model that was designed to be very rigid. This paper presents the results of an investigation of the deformations of the wing model during the tunnel tests and the effects these deformations have on the wing aerodynamics.

In the study a finite-element model (FEM) of the wing was developed and then, for conditions corresponding to wind tunnel test points, experimental aerodynamic loads and analytical aerodynamic loads were applied to the FEM. Comparisons were made between experimental loads and analytical loads for changes, along the wing span, in lift per angle of attack, in center-of-pressure locations, in bending deflections, and in torsional rotations.

The results from this study show good correlation between the analytical and experimental data. They also show that the deformations are quite small and that the experimental pressure data were not significantly affected by model deformations.

HIGH ALTITUDE, SOLAR POWERED PLATFORM. James W. Youngblood,* NASA Langley Res. Ctr., Hampton, Va. 23665

An unmanned, high-altitude, solar-powered electric airplane is proposed. Remotely piloted from the ground, the propeller-driven craft obtains power for payload and propulsion from on-board solar energy collectors. Stored energy enables overnight flight, allowing the airplane to remain on station for up to months at a time. This unique capability could be exploited in design of long-duration reconnaissance, communications, and remote monitoring platforms for local or regional mission applications.

Theoretical performance is calculated such that 24-hour level flight is enabled at "equilibrium" altitude; i.e., excess solar energy, stored around midday, matches the energy required for overnight flight. Results are presented to illustrate enabling technology areas critical to vehicle development: (1) materials and structures for ultra-low airframe wing loading; (2) high efficiency aerodynamic components for low Reynolds number flight; (3) high specific energy storage devices.

The data illustrate effects of date, latitude, atmosphere transmissivity characteristics, and payload power requirements on vehicle performance (altitude and flight duration) and design requirements (e.g., efficiency and orientation of solar collectors, aerodynamic characteristics, and size of power train and energy storage systems). Airplane sizing data, in terms of wing area, are presented for representative payload mass and power requirements.

Agricultural Sciences

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

INFLUENCE OF RESTRICTED GROWTH AND ELEVATED CALCIUM AND PHOSPHORUS LEVELS ON FOOT, METACARPAL AND METATARSAL CHARACTERISTICS OF CONFINEMENT-REARED SOWS. S. R. Arthur, E. T. Kornegay, R. A. Barczewski, K. E. Webb, Jr., H. P. Veit and D. R. Notter. Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

Gilts which had previously been fed ad lib or 75% ad lib intake and 100 or 150% NRC daily Ca and P levels from weaning to 100 kg were selected for the reproductive study and fed a balanced gestation-lactation diet. Foot and leg measurements and subjective toe scores were taken 21 days postweaning for three parities. Foot, horn and toe length and toe width were measured on both front and rear feet. Bone samples were taken from sows culled due to lameness or failure to breed and from sows completing three parities. All toe measurements (TM) increased over time. Outside TM were larger than inside TM and rear TM were larger than front TM. Rear outside TM were always larger than front outside TM. Toe volumes and areas were smaller for previously restricted-fed sows through three parities. Pad and horn scores improved over time with the hind outside toe having the least desirable score through-out all three parities. Sows previously fed 150% Ca and P had longer and wider metacarpals and metatarsals that were thicker at the narrow and perpendicular dimensions. Bones of sows previously fed 150% Ca and P contained more ash and less fat. Previously restricted-fed sows had metatarsals that contained more calcium and more P as a percent of dried fat-free bone with more ash and less fat than metatarsals of the previously ad lib-fed sows.

THE EFFECT OF TWO LEVELS OF CALCIUM AND PHOSPHORUS AND ENERGY INTAKES ON GAIT PARAMETERS IN SOWS OVER THREE PARITIES. R. A. Barczewski¹, E. T. Kornegay, S. R. Arthur, A. J. Lepine², A. F. Harper², H. P. Veit², D. R. Notter, H. R. Thomas and J. W. Knight. VPI & SU, Blacksburg, Va. 24061

A study was conducted to determine the effects of early nutrition (ad lib vs 75% ad lib and 100 vs 150% of NRC daily Ca and P) on gait characteristics of sows over three parities. Gilts were maintained on these treatments throughout the growing period. At 100 kg, all gilts were placed on a standard (14% crude protein) ration. Approximately 21 days postweaning the sows were filmed with 16 mm film while walking on a treadmill. Film was edited on a Lafayette film analyzer to identify the most natural gaits and measurements were taken. No differences were observed in distance to arc point and angle at the flex. Findings indicate that over time sows became longer, taller and deeper in girth (P<.01). Increases were also observed in height of arc point (P<.05) and height of front foot (P<.001), whereas, front (P<.001) and rear (P<.06) pastern angles, height of rear foot (P<.03) and angle of hock (P<.002) decreased over time. Previously ad lib fed sows were taller, 72.1 vs 70.9 cm, (P<.001) than restricted fed sows, while sows fed 100% NRC Ca and P during the growing period were shorter, 70.5 vs 72.5 cm, than sows fed the 150% Ca and P diets. There was a tendency (P<.08) for sows previously fed ad lib intakes to be straighter in their pasterns than restricted fed animals.

RELEASE RATE OF PROGESTERONE FROM INDWELLING ELASTOMER

IMPLANTS IN SWINE. M. L. Barber¹, J. W. Knight and F. C. Gwazduska. Depts. of Animal and Dairy Science, VPI&SU, Blacksburg, VA 24061

Previous studies by our group have demonstrated that daily subcutaneous injections of exogenous progesterone (P) and estrone (E) in a 2000:1 ratio elicited beneficial effects on porcine placental growth and development when administered during discrete periods of early gestation. However, daily injections represented a labor inefficient method of delivery, subjected the gilts to considerable stress and resulted in a surge of steroids rather than a more physiological rate of release. Investigations currently in progress utilize an indwelling elastomer implant approximately 100 x 3 mm containing 2 g P/1 mg E. This dose level was determined based upon this preliminary study examining dosage level/implant (2 g P/1 mg E vs 4 g P/2 mg E, no. of implants (1 vs 2) and total dosage level/gilt (2 g P/mg E, 4 g P/2 mg E, 8 g P/4 mg E). Four ovariectomized gilts were utilized. Systemic P concentrations were measured daily and over a consecutive 24-hr period under each treatment regime. It was concluded that 1 implant containing 2 g P/1 mg E represented the most efficient treatment. The release rate from one 2 g P/1 mg E implant of 16.67 ± 1.71 ng/ml approximated systemic P concentrations during pregnancy. No compensatory increase was demonstrated when either number of implants or dosage/implant was doubled. Variation in release over a 24-hr period was observed.

THE DEMAND AND ALLOCATION OF U.S. APPLES WITH SOUTHEASTERN IMPLICATIONS. H. S. Baumes, Jr., Dept. of Ag. Econ., Virginia Tech., Blacksburg, VA 24061

The objectives of this paper are to theorize and estimate an econometric model of the demand and allocation structure of the U.S. apple sector. The apple sector is disaggregated into fresh and processing markets and grower and retail market levels are specified. An impact multiplier analysis is included.

Given the estimated model a regional pesticide withdrawal scenario is discussed. On a regional basis total utilization and allocation of apples to the fresh market deviate slightly from the national average. Price impacts resulting from a national production loss and a production loss in the southeast are very similar. For each loss of 100 million pounds of production prices increase .14, .07, .22, and .05 cents per pound for retail market fresh apples, farm level fresh apples, retail market processing apples, and farm level processing apples, respectively.

A SELECTION PROGRAM FOR IMPROVING SOW PRODUCTIVITY. K. P. Bovard, D. C. Almes^a and C. R. Cooper^b. Dept. of Animal Science and Computing Center, VPI & SU, Blacksburg, VA 24060.

In September 1980, Virginia Tech received a copy of a computer program to evaluate sow productivity, based on litter size--both number born alive and number raised to weaning--and litter weight at about 21 days of age. The program was developed by Keith Irvin of Ohio State University, and was written for use with the SAS (Statistical Analysis System) library of programs applied to the IBM-370. In order to calculate each sow's productivity index, the program requires identification of each sow, her sire, and the sire producing each of her litters. Performance data cited above and farrowing data are entered for each litter of a contemporary group--all litters born in a 4-6 week period. Summary results provide a ranking of 1) sows in the most recent contemporary group, 2) all sows with records in the system, 3) sow families as defined by the producer, and 4) sires of sows. The program is a tool for purebred and commercial breeders to improve litter size and litter weight.

SUPPLEMENTAL BIOTIN FOR GLITS AND SOWS HOUSED IN TOTAL CONFINEMENT: A PRELIMINARY REPORT. K. L. Bryant^a, E. T. Kornegay, J. W. Knight and K. E. Webb, Jr., Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

One hundred and sixteen crossbred glits were utilized in a 2 x 2 factorial design to evaluate the effects of corn (C) and wheat (W) diets supplemented with either 0 (-B) or 440 ug/kg (+B) biotin on reproductive performance, foot lesions and hair characteristics of glits and sows housed in total confinement for two parties. Conception rates, although not significantly (P>.10) different, favored C and +B females. Days to estrus following weaning were lower for C and +B sows. Although differences were not significant (P>.10), all farrowing and lactation criteria favored the +B females. Females fed C diets had heavier pigs at birth (P<.03) and 21 days (P<.04) compared with W-fed females. Plasma biotin concentrations (PBC) were not different (P>.10) for C and W diets; however, PBC were higher (P<.008) at all sampling times for +B females. Females consuming W diets had a higher (P<.001) incidence and severity (P<.11) of heel-core erosion than females fed C diets. There was a trend for reduced incidence of heel cracks for +B females, while the severity of these heel cracks were reduced (P<.04) by B supplementation. The incidence of heel-toe junction cracks and side wall cracks were lower (P<.03) for +B females. Biotin supplemented females had more hairs per cm² (P<.03) and better hair scores (P<.001) compared to -B females.

INFLUENCE OF BREEDING, SEX AND AGE ON PERFORMANCE OF CATTLE WINTERED ON POOR QUALITY HAY. Michele Cochran^a, W. H. McClure^a, Isabelle Ortigues^a, K. P. Bovard and J. P. Fontenot. Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Sixty steers and heifers of variable age, weight and breeding were wintered on coarse predominantly tall fescue hay alone and with different protein supplements. All cattle were implanted with Ralgro. Shrink weights were taken initially, after 71 days and at the end of the trial (119 days). Age varied from 296 to 662 days and initial weights varied from 173 to 365 kg. The types of breeding were straightbred Angus, Simmental-Hereford-Angus cross and three-way and two-way British breed crosses. Daily gains were highest for the three breed (.28 kg) and lowest for the two breed (.19 kg) crosses. Performance was intermediate for the other cattle. No marked differences were observed in daily gain between steers and heifers. The values were .16 kg for steers and .17 kg for heifers. Daily gain was .09 kg for calves, compared to .15 and .19 for yearlings and 2-year-olds, respectively. However, the statistical correlation was low between age at the beginning of the feeding period and daily gain. Initial weight was correlated with daily gain. Daily gains were .08, .17 and .20 kg for cattle with initial weights of 173-213, 229-295 and 296-365 kg, respectively. The correlation coefficient was .33 (P<.01).

BREED OF SIRE EFFECT ON CONCEPTION, CALF SURVIVAL AND COW PRODUCTIVITY. R. A. Brown^a, T. J. Harlowe and E. A. Tolley, Dept. of Animal Science, VPI&SU, Blacksburg, Va 24061

Sire breed effects were evaluated on 581 Angus cows and 1378 Hereford cows at two locations. Angus (A), Hereford (H), Shorthorn (Sh), Brown Swiss (BS), Holstein (F) and Charolais (C) sire breeds were involved. Growth parameters include average daily gain (ADG), actual weaning weight (WWT), and adjusted 205-day weight (ADJ 205). Reproductive parameters are comprised of perinatal mortality (death w/in 72 hr), total calf mortality, % open cows, % dead or culled cows, and % weaned. Growth data were analyzed using Harvey's least squares procedure. The model included sire breed, year, sex, dam age, sire x year and age. The reproductive parameters were analyzed using Harvey's Least Squares Analysis of Discrete Data. The model included sire breed, year, dam age and sire x year. Using kg of calf weaned per cow exposed, C (.191 + .05) were superior to F (.172 + .06) and A (.162 + .06) when sired to A cows at Southampton. Sire breed, year, sex and dam age were highly sig (P<.001) for ADG, WWT and ADJ 205. Sire breed was not sig for any reproductive parameters. In the H base cow herd at State Farm, sire breeds ranked by kg calf weaned per cow exposed were F (.145 + .006), C (.133 + .008), Sh (.133 + .01), BS (.123 + .01), H (.117 + .004) and A (.102 + .01). All sources of variation were highly sig (P<.001) for growth parameters. Sire breed was sig (P<.01) only for % weaned in reproductive performance characteristics.

MODELING DIAMETER DISTRIBUTION WITH A BIMODAL PROBABILITY DENSITY FUNCTION. Q. V. Cao^a. Biometrics Section, Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Diameter distributions can be either unimodal or bimodal. Whereas unimodal probability density functions (pdf) have been often used to model diameter distributions, little work has been done concerning bimodal pdf's. A new probability density function which can be either bimodal or unimodal was developed.

Let Z be a standard normal variable and X be a positive random variable. Using the transformation

$$Z = g(X) = \begin{cases} g_1(X) = a + b \ln(X), & 0 < X \leq t, \\ g_2(X) = p + q c^X, & t < X < \infty, \end{cases}$$

where $g_1(X)$ and $g_2(X)$ are continuous such that $g(X)$ is smooth and continuous at the join point t , the pdf for X is derived:

$$f(x) = \begin{cases} (2\pi)^{-1/2} (b/x) \exp\{-[a+b\ln(x)]^2/2\}, & 0 < x \leq t, \\ (2\pi)^{-1/2} (b/t) c^{x-t} \exp\{-[p+qc^x]^2/2\}, & t < x < \infty, \\ 0, & \text{otherwise} \end{cases}$$

where $q = b/[t^2 \ln(c)]$ and $p = a + b \ln(t) - qc^t$.

An iterative procedure was developed to obtain the maximum likelihood estimators for a , b , c , and t .

METHOMYL: ITS PLACE IN AN IPM PROGRAM FOR APPLES. Paul J. David and Robert L. Horsburgh, Dept. of Entomology, Winchester Fruit Res. Lab., VPI & SU, Winchester, VA 22601.

For many orchard pests, especially leafrollers, the egg stage is the weakest point in the life cycle. Methomyl, used as an ovicide/larvicide, can be an effective control measure for many of these pests. Being a short residual insecticide, the compound can be applied at the optimum time for maximum effectiveness and minimal effect on the parasite/predator complex. Laboratory tests on the eggs of pest and beneficial insects illustrated that methomyl can be applied at a rate of 0.26 g AI/l, one-half the recommended rate, and still provide adequate control of pest species with minimal effects on some of the more important predatory insects. A predictive, temperature-driven model is being developed to predict pest development. Once the model is validated, ovicide/larvicide sprays using methomyl can be accurately timed for optimal effectiveness.

PRELIMINARY STUDIES ON THE PHENOLOGY OF THE EUROPEAN CORN BORER, *OSTRINIA NUBIALIS* (HUBNER) (LEPIDOPTERA:PYRALIDAE), IN WESTERN VIRGINIA. Joseph L. Despins* and James E. Roberts, Sr., Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Ostrinia nubilalis (Hubner) has long been a pest of corn in Virginia. During the 1977-79 growing seasons, first generation *O. nubilalis* became especially pestiferous. The purpose of this research was to measure the development of this insect in the field through the accumulation of heat units (degree-days). Such information is necessary for the timely initiation of scouting activities in the western regions of the state.

Spring pupae were first collected, and pupation peaked and ended at 89, 422 and 579 degree-days, respectively. Peak spring moth flight and peak oviposition occurred with an accumulation of 497 degree-days. Initiation of summer moth flight, peak summer flight and peak late summer flight appeared with temperature accumulations of 935, 1163 and 1714 degree-days, respectively.

FEASIBILITY STUDY OF OILSEED SUNFLOWER PRODUCTION ON LANDS RECLAIMED FROM THE STRIP-MINING OF COAL. R. D. Fell and D. M. Orcutt. Dept. of Entomology and Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, Va. 24061.

Three varieties of oilseed sunflowers (Northrup King; Sunbred 212, 254 and 265) were planted on recently reclaimed lands at a site in Wise County, Va. The plants were sown at a density of 54,000 plants/hectare in a research plot measuring 15x46 m. Ground preparations were minimal. Plant growth, seed production and seed oil content were determined for each variety. The effects of a plant growth regulator (Cycocel) and the varietal needs for cross pollination were examined also. The PGR was applied at a rate of 12 kg AI/hectare when plants reached a height of 15-20 cm. The needs for cross pollination were examined by covering flower heads during bloom with plastic screen bags and comparing the resultant seed production with open pollinated plants.

Large differences in growth and productivity were found between the varieties tested. The most productive variety was S-212, followed by S-254 and S-265, respectively. The estimated net seed yield (dry wt.) of S-212 was 988 kg. Mean seed oil content was 17.8 mg/seed (48% by wt.) for S-212 and 5.90 mg/seed (31% by wt.) for S-254. No significant differences in productivity were noted after treatment of plants with Cycocel or between open-pollinated and bagged heads. The lack of significant differences in the pollination treatments may have been partially due to the low numbers of pollinators observed in the field (< 7 bees/100 flowering heads).

EVALUATION OF GRASS- AND GRAIN-FED BEEF BY TRAINED MEAT PANELISTS AND BY CONSUMERS. W. V. Fredrick*, K. P. Bovard, P. P. Graham*, J. P. Fontenot and R. F. Kelly*. Departments of Animal Science and Food Science and Technology, VPI & SU, Blacksburg, Va. 24061.

For four successive years, steers from an experiment comparing forage management systems were slaughtered and carcass traits and composition recorded on each animal. Seven forage-grain combinations were compared, with six steers per treatment fed at each of two locations, Glade Spring and Middleburg. At slaughter, rib and loin sections were fabricated. Sample roasts were cut from the 6-7-8 rib section and sent to a cooperator (Beltsville) for evaluation by a professionally trained taste panel (PTP). Steaks were cut from the loin section, identified and packaged in pairs, one from each of two treatments, i.e., 1-2, 1-3, 1-4, ..., 5-7, 6-7. These pairs were later evaluated by a panel of local consumers (CTP) stratified by age and socio-economic status. The PTP rated roasts from cattle receiving grain more palatable than those from cattle fed forage only. The CTP generally preferred loin steaks from grain-fed cattle to those from cattle receiving forage only; but the preferred steaks were less acceptable to the consumers than comparable cuts available commercially.

ANIMAL PROTEINS WITH AND WITHOUT TRYPTOPHAN AS PROTEIN SUPPLEMENTS FOR GROWING SWINE. K. M. Elmer*, C. C. Brooks and E. T. Korngay, Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061 and W. I. Hugh*, Dept. of Animal Science, Univ. of Hawaii, Honolulu, HI. 96844.

Thirty growing pigs (6/treatment) were used in a feeding trial to study the influence of supplemental tryptophan for tuna meal and meat and bone meal diets on growth and bone mineralization. Dietary treatments were: (1) corn-soybean meal (CS), (2) corn-tuna meal (CT), (3) CT plus .075 tryptophan (CTT), (4) corn-meat and bone meal (CM) and (5) CM plus .075% tryptophan (CMT). Pigs were *ad libitum* fed from an initial weight of 44 lb to a final weight of 185 pounds. Radius and tibia were used for bone analysis. Pigs fed CS diets grew faster ($P<.001$) than pigs fed CT, CTT, CM and CMT diets (1.69 vs 1.30, 1.43, .98 and 1.48 lb, respectively). Tryptophan improved gains ($P<.001$) of pigs fed both CT and CM diets. Dry matter percentage of the radius and tibia (diaphysis and proximal epiphysis) was less for pigs fed CS compared to the other diets. Radius volume (ml) was greater for pigs fed CS compared to the other diets, but was not different between diets for the tibia. Breaking strength of both radius and tibia was increased when tryptophan was added to CT and CM diets with a greater response when added to CM diets. Dry matter percentage of the epiphysis of the tibia was decreased when tryptophan was added to the diets, but was not different for the radius. Pigs fed the CS diet had a lower dry matter percentage of the radius epiphysis than pigs fed the other diets.

CALIBRATION OF SWEEP NET SAMPLING FOR POTATO LEAFHOPPER IN ALFALFA. S. J. Fleischer*, W. A. Allen, J. M. Luna*, and R. L. Pienkowski. Dept. of Entomology, VPI&SU, Blacksburg, VA 24061.

A calibration equation is developed that relates mean pendular sweep net catch of potato leafhoppers in a given field to the absolute density. A comparison of 3 absolute density techniques showed that the D-Vac[®], and a modified Echo[®] suction sampler operated with a lightweight drop trap yielded accurate estimates upon which the calibration equation was based. The D-Vac did not need calibration, and sampling several meters ahead of the sampler to avoid disturbing the leafhoppers gave no measurable advantage. Multiple regression with crop and environmental parameters did not improve the fit of the calibration. Robust regression helped identify outliers that were related to harvesting practice or uniformity of alfalfa stand. Mean sweep net catch (\bar{x}) was a univariate linear function of mean absolute density (\bar{y}) by the formula $\bar{x} = 18.5\bar{y}$, with an R^2 of 83%. Analysis of the frequency distribution generally followed a Poisson series, and deviations from this pattern were related to those fields identified as outliers.

MAGNESIUM METABOLISM IN SHEEP FED DIFFERENT LEVELS OF SOLUBLE CARBOHYDRATE AND POTASSIUM. S.A. Giduck*, J.P. Fontenot, J. Herbelin*, L.W. Greene* and K.E. Webb, Jr.* Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Two metabolism trials were conducted with 12 wether lambs equipped with abomasal and ileal cannulae. A 2x2 factorial arrangement was used with 3 and 23% soluble carbohydrate and .6 and 4% potassium (K), dry basis. Each trial consisted of a 10-day preliminary period followed by a 7-day collection of feed, feces and urine and a 6-day sampling of feed, abomasal and ileal fluid, and feces. Chromic oxide was used to measure flow through the digestive tract. Magnesium absorption was not affected by level of soluble carbohydrate. High K decreased magnesium absorption ($P<.01$). Urinary magnesium excretion decreased at the high K level ($P<.01$). The primary site of magnesium absorption was preintestinal. High K tended to depress magnesium absorption in this area, but had no effect in the intestines. High soluble carbohydrate had no effect on preintestinal magnesium absorption, but tended to increase magnesium absorption in the large intestine. Increased K in the diet resulted in an increase in K absorbed, ($P<.01$). The primary site of K absorption at the low level of K was the small intestine, but at the high level the stomach was important also. Serum magnesium and calcium tended to be depressed at the high K level. High dietary K increased serum K ($P<.05$), but high soluble carbohydrate tended to decrease it.

SITE OF MAGNESIUM ABSORPTION IN STEERS FED HIGH LEVELS OF POTASSIUM. L.W. Greene*, J. P. Fontenot and K. E. Webb, Jr.* Dept. of Animal Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Six crossbred steers, average initial weight, 261 kg, were surgically equipped with abomasal and ileal cannulae to determine the site of magnesium absorption. Three metabolism trials were conducted with a 10-day preliminary period, a 7-day collection of feed, feces and urine and a 6-day sampling of feed, feces, abomasal and ileal fluid. Three levels of potassium (K) (.6, 2.4 and 4.8%, dry basis) were fed in a randomized block design. Chronic oxide was used as an indicator to measure flow through the digestive tract.

Magnesium (Mg) absorption decreased linearly ($P < .05$) when high levels of K were fed. The primary site of Mg absorption was in the preintestinal region, followed by a net secretion into the small and large intestine. When the high level of K was fed, preintestinal Mg absorption decreased ($P < .05$), smaller amounts of Mg were secreted into the small intestine and serum Mg was depressed.

Potassium absorption and retention increased ($P < .05$) with increasing levels of K. The intestinal regions were the primary sites of K absorption when the low level of K was fed, but with the higher levels of K intake, the preintestinal region was also an important site of absorption.

Magnesium absorption in steers was similar to those observed previously in sheep when high levels of K were fed.

EFFICACY OF VIRGINIAMYCIN AND A LACTOBACILLUS CULTURE IN SWINE DIETS. A. F. Harper*, E. T. Kornegay, K. L. Bryant* and R. H. Thomas. VPI & SU, Blacksburg, Va. 24061

Six trials using 600 crossbred pigs were conducted to evaluate the addition of virginiamycin (VIR) and lactobacillus (LAC) to swine diets. VIR was added at a level of 11 mg/kg of diet and LAC at a level of 1000 mg/kg in starter diets and 500 mg/kg in grower and finisher diets. In three starter trials, daily gain, daily feed intake, and feed efficiency were not significantly different between dietary treatments. During the starter phase of a fourth trial, pigs grew faster when fed diets containing VIR or chlorotetracycline, penicillin and sulfamethazine (ASP 250) compared with pigs fed the control or a LAC containing diet. During the grower and finisher phase and overall for this trial, daily gain and daily feed intake were lower for pigs fed the LAC containing diet than for the ASP 250 containing diet with intermediate values observed for the control pigs and pigs fed the VIR containing diet. In two grower-finisher trials where VIR and LAC were compared in a 2×2 factorial arrangement of treatments, daily gain and feed intake were greater for pigs fed diets containing VIR. In one of the two trials, a significant VIR times LAC interaction was observed; in the absence of VIR, daily gain and feed intake were improved when LAC was added to the diet, but they were depressed in the presence of VIR. Feed per gain ratios were not significantly different between treatments. These data suggest that VIR and LAC should not be used in combination.

AN EXAMINATION AND CHARACTERIZATION OF TRUE HERMAPHRODITE AND MALE PSEUDOTHERMAPHRODITE IN SWINE. J. W. Knight, Dept. of Animal Science, VPI&SU, Blacksburg, Va. 24061

Two male pseudothermaphrodites (PH) and 2 true hermaphrodites (H) were examined endocrinologically, histologically and morphologically. Indwelling catheters were surgically placed into the anterior vena cava of each to enable frequent blood sample collection. Blood samples were taken either every 30 min (PH) or 60 min (H) for a consecutive 24 hour period, as well as once per day for approximately 3 weeks to ascertain an endocrine profile. Hormones measured were testosterone (T), progesterone (P), glucocorticoids (GC) and luteinizing hormone (LH). Repeated (every 15 or 30 min) blood samples were also collected pre- and post-administration of various exogenous hormone challenges to measure their endocrine response capabilities. Endocrine data includes the following: for PH 1, diurnal T ranged from 5-2.6 ng/ml with 2 major peaks at 10-hr intervals; PH 2 had T values of .2-1.0 ng/ml with 2 major peaks at 16-hr intervals and GC concentrations of 5-63 ng/ml; H 1 had daily T values of .2-2.7 ng/ml over the 3 week sampling period, P values of .2-16.9 ng/ml, suggesting cyclicity and LH levels <1 ng/ml; H 2 had T levels of .1-1.9 ng/ml, P values of .1-1.9 ng/ml and LH concentrations of <1 ng/ml. Both PH had only testicular (no ovarian) tissue, but possessed all other components of both male and female reproductive traits. Both H had a testis as the right gonad and ovary as the left gonad and varying amounts of male and female reproductive tract development.

PRECIPITATION AND AIR TEMPERATURE EXTREMES SINCE 1933 AT HOLLAND IE STATION. D. L. Hallock* Tidewater Res. and Continuing Education Ctr., VPI&SU, Suffolk, Va. 23437.

Considerable variance has occurred in air temperatures and precipitation during the past 48 years. The highest average monthly maximum temperature was 92°F which occurred July 1942 and 1952. The lowest average monthly maximum was 40°F which occurred Jan. 1940. Daily maximum temperatures attained 105°F in June 1952 and July 1942. The highest average monthly minimum temperature of 72°F occurred July 1949 whereas the lowest (18°F) occurred Jan. 1940. Daily minimum temperatures were as low as -3°F in Jan. 1940 and Feb. 1936. The average distribution of rainfall is excellent for crop production. Total monthly rainfall has varied from 15.57 in August 1949 to only 0.21 in. in Sept. 1958. Annual rainfall has varied from 63.49 in. in 1949 to 33.40 in. in 1980, the driest year on record at this Station. The highest recorded rainfall for any day was 6.41 in. (1949). For the June to Aug. period, the highest rainfall of 32.58 in. occurred in 1949 and the lowest 4.28 in. in 1980. Normal rainfall for this period is 16.32 in. Annual snowfall was highest ever during 1980, being 34.5 in. The 48-year mean is 7.5 in. There have been 8 years with less than 0.5 in. of snow during these 48 years. Extremes for killing frosts (32°F) are Oct 2 (1947) and Nov. 15 (1938) or Mar. 15 (1935) and May 11 (1947, 66). The average dates are Oct. 20 and April 15, giving a frost-free (+32°F) season of ca 195 days.

SYNERGISTIC INTERACTION OF TERBUTHIURON WITH ALACHLOR AND METOLACHLOR IN CORN IN THE PRESENCE OF THE HERBICIDE ANTIDOTE R-25788. K. K. Hatzios*, Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Combination treatments of the herbicide terbuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimethylurea) with the herbicides alachlor (2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide) and metolachlor (2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide) in the presence of the herbicide antidote R-25788 (2,2-dichloro-N,N-diallylacetamide) interacted synergistically when applied to corn (*Zea mays* L., cv. 'Pioneer 3780') under greenhouse conditions. Alachlor and metolachlor were applied preplant incorporated at rates of 1.12, 2.24, 4.48, and 6.72 kg/ha, all combined with 0.56 kg/ha of R-25788, and they were evaluated against 0.28, 0.56, and 1.12 kg/ha of preemergence applications of terbuthiuron. Shoot dry weight and shoot height were the parameters measured and the synergistic interactions were evaluated by the methods of orthogonal comparisons and Colby. It is suggested that terbuthiuron may act as an inhibitor of a microsomal enzyme system that is possibly involved in the metabolism of the acetanilide herbicides alachlor and metolachlor in corn. This action of terbuthiuron may counteract a possible stimulatory effect of the antidote R-25788 on this enzyme.

CITRIC ACID FOR WEANED PIGS. E. T. Kornegay and K. L. Bryant* Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061

Citric acid which has been suggested as having a beneficial influence on feedlot performance of growing swine was evaluated in two trials using weaned pigs. In trial 1, four pens of pigs (5/pen) averaging 16.2 lb were fed each of the following diets: (1) basal, (2) basal plus 2% citric acid and (3) basal plus 5 lb/ton of chlorotetracycline, penicillin and sulfamethazine (ASP 250). In trial 2, two pens of pigs (6/pen) averaging 12.9 lb were fed a basal diet and a diet with 2% citric acid. Pigs were on test for six weeks in both trials. A 22% crude protein corn-soybean meal diet containing 10% dried whey was fed from weaning until pigs in a pen averaged 15 lb, a 20% protein diet was fed to 25 lb, and an 18% protein diet without the whey was fed for the remainder of the test. Feed and water were offered *ad libitum*. In trial 1, daily gain and feed intake were greatest for pigs fed the diet containing ASP 250, intermediate for pigs fed the diet containing citric acid and lowest for pigs fed the basal diet. Feed per gain, although not statistically different, favored pigs fed citric acid and ASP 250. In trial 2, pigs fed citric acid grew faster ($P < .05$) and consumed a nonsignificant greater amount of diet. As in trial 1, feed per gain in trial 2 favored pigs fed the diet with citric acid. In summary, 2% citric acid added to starter diets improved feed intake and feed efficiency which resulted in a faster growth rate.

DEVELOPMENT OF FOOT, LEG AND TOE CHARACTERISTICS OF BOARS FED REDUCED ENERGY LEVELS AND ELEVATED MINERAL AND VITAMIN LEVELS A. J. Lepine¹, E. T. Kornegay, D. R. Notter, H. P. Veit, J. W. Knight, K. L. Bryant², H. S. Bartlett³ AND R. A. Barczewski⁴, VPI & SU, Blacksburg, VA, 24061

Eighty crossbred boars were used in a 2 x 2 factorial design to evaluate the effects of treatments (ad lib vs 75% of ad lib intake and 100 vs 150% of NRC minerals and vitamins) on foot and leg measurements and subjective toe scores taken at approximately 28, 120, 210, 290 and 330 days of age. Randomly selected boars were necropsied at 15 day intervals starting at 120 days of age. Length and width of front and rear inside and outside toes, length of metacarpal, metatarsal, tibia and ulna, and circumference of carpal and tarsal joints were large for ad lib-fed (AL) compared with restricted-fed (RT) boars when compared at a similar age; the reverse was observed when these parameters were compared on an equal weight basis. Elevated mineral and vitamin levels had no effect on the above parameters. Pad and horn scores were generally not affected by energy or mineral and vitamin level, although after 120 days, scores were slightly more favorable for boars fed 100% NRC minerals and vitamins. Pad and horn scores were generally higher (less favorable) for outside compared with inside toes of both front and rear feet. Outside pad scores increased to about 210 days and then remained similar for the remainder of the test; inside pad scores tended to decrease over time. Horn scores were low for both inside and outside toes of both front and rear feet, but were always much lower for the inside toes.

PERFORMANCE COMPARISON OF STRAIGHTBRED, SINGLE CROSS AND THREE-WAY CROSS COWS AT THREE LOCATIONS. Thomas J. Marlowe and Elizabeth A. Tolley, Dept. of Animal Science, VPI&SU, Blacksburg, VA, 24061

Three cow types were compared at three locations based on 518 matings to same kind of bulls for two calf crops. Stat model included cow type, location, year, sex, cow age, calf age and interaction of CT x Loc, CT x Yr and Loc x Yr. All variables significantly influenced weaning weight except CT x Yr interaction. $R^2 = 0.63$. Location (herd) had a major effect on both cow and calf performance. % open cows were 2.9 at Bland, 17.0 at Hanover and 18.6 at State Farm. Corresponding calf losses were 11.1, 15.7 and 13.0%; likewise, % calves weaned was 85.4, 70.4 and 69.4. Calves graded lower and were thinner at Hanover with Bland calves intermediate. Corresponding lb calf wt/cow exposed were 381, 238 and 350 lbs. No difference in 2WX and 3WX cows, both of which were superior to SB cows in calf wean wt but not in % calf crop wt. % cows open were 5.1, 14.8 and 13.4; % calf loss was 14.7, 10.2 and 13.6; and % calf crop wt was 78.1, 75.9 and 74.8 for SB, 2WX and 3WX, respectively. Corresponding wean wts were 403, 440 and 444 lbs and lb calf wt/cow exposed were 315, 334 and 332 lb. There was no difference in grade or condition score due to cow type.

BIOLOGICAL STUDIES OF CEUTOZYCHUS PUNCTIGER GYL. (COLEOPTERA: CURCULIONIDAE), A DANDELION SEED-FEEDING WEEVIL. T. J. McAvoy¹ and L. F. Kok, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Studies on the field biology of *Ceutozychus punctiger*, a weevil found infesting dandelions in Allegheny, Augusta, Frederick, Grayson, Highland, Montgomery, Pulaski, and Warren counties, were conducted during April and May in 1979 and 1980 in Blacksburg, VA. Dandelion growth stages were distinguished by grouping them in twelve categories (1-12). Eggs, up to 2.1 bud, were observed during the first few days of April when the rays of the closed bud were still white (2). There were three larval instars. First instars were initially found in the 2nd week of April when the bud's outer sepals were open and the stem not elongate (4). Second instars were first collected during the 4th week of April when the flower had opened (6) and third instars were found when the flower was closed and the rays were dry and brown (8). All immature stages were collected up to but not after the 2nd week of May when the seed head opened and the seeds were exposed (10). The three instars averaged 6, 5, and 17 days and the pupal stage 22 days. Larval head capsule size was 0.35, 0.50, and 0.67 mm and body length was 1.15, 2.07, and 3.38 mm for the three instars, respectively. Development from egg to adult emergence was 50 days. Seed consumption/larva was 22.8 ± 10.2 from a mean of 162.8 ± 40.5 dandelion seeds/head.

VIRGINIA'S FRESH APPLE MARKETS. J. Love¹ and H. S. Baumes, Jr., Dept. of Ag. Econ., Virginia Tech., Blacksburg, VA 24061

Virginia apple production has average 411 million pounds, annually since 1964. In 1980, Virginia produced 390 million pounds. In 1979, 470 million pounds were produced, of which 140 million pounds (30%) went for fresh market utilization. Since 1964, an increasing proportion of VA fresh production has been marketed within the state - up to 34% of the 1979-1980 crop. The remaining two-thirds of fresh production has been marketed to other states, principally in the East and South.

Eighty to 90% of VA fresh apples which are shipped to other states go to 12 major cities. The top four cities are (have been) Atlanta, Baltimore-Washington, Miami, and New York. A descriptive analysis was presented of changes in the total fresh apples received by these cities and the impact of other contributing states on the competitive position of VA.

INFLUENCE OF COW TYPE ON COW AND CALF PERFORMANCE. T. J. Marlowe, W. E. Burgess² and W. H. Gillette³, Dept. of Animal Science, VPI&SU, Blacksburg, and Southampton Correctional Center, Capron, VA.

Cow types compared were Angus (A) producing either straight (AA) or crossbred (AX) calves, Charolais x Angus (CA), Holstein x Angus (FA) and two 4-bred composites. Both composites were 1/4 A, 1/4 Hereford (H), 1/4 Simmental (S) and either 1/4 Charolais (C) or 1/4 Holstein (F). All cows were bred to AA bulls for 1st calf. Thereafter, half of AA and all CA and FA cows were bred to SH bulls and 4-way cows (SHCA, SHFA) to 4-way bulls. All cattle were treated alike. Avg. age of AA, AX, CA and FA cows was older than for 4-way cows. Based on 661 matings over 6 calf crops, overall calving % was 89.2, ranging from 86% for AX to 92.5% for SHFA. 205-day weight ranged from 421 lb for AA to 546 lb for SHFA. lb calf weaned/cow exposed ranged from 364 for AA to 505 for SHFA. All crossbred (XB) cows outperformed straightbred (SB) cows, with SHFA composite superior to all others. FA cows were superior to CA cows (39 lb/cow exp); 4-way (SHCA, SHFA) were superior to single cross (CA, FA) by 33 lb; and SHFA to SHCA by 32 lbs. Best composite (SHFA) beat AA cows by 141 lb/cow exposed.

TRAP CROPS FOR CONTROLLING SOYBEAN INSECT PESTS. R. M. McPherson, Va. Polytechnic Inst. and State Univ., East. VA. Res. Stn., Warsaw, VA 22572, and J. C. Smith, V. P. I. & S. U., Tidewater Res. and Cont. Ed. Ctr., Suffolk, VA, 23437.

Early-planted soybean fields were evaluated in 1980 for attracting overwintered Mexican bean beetles, bean leaf beetles, stink bugs, and Arthropod predators. 'Trap Crops' plus nine additional later-planted soybean fields adjacent to the traps were sampled with a 38-cm sweep net weekly in Westmoreland and Richmond counties. Mexican bean beetles were very heavy in both trap crops in early season. Populations in adjacent full-season and double-cropped fields were low throughout the year. Bean leaf beetle adults were present in high numbers only in the Westmoreland trap crop. First and 2nd generation adults were observed in late-June and late-July. Stink bug population densities approached economic threshold levels in the Westmoreland trap on 8 Aug. No other fields had significant populations of this pest.

Spider population densities were not significantly different in any of the fields sampled. Big-eyed bugs and nabids were significantly more abundant in the trap crops and other full season fields than in the double-cropped soybeans. Lady bugs were most numerous in the double-cropped fields.

SUBLETHAL EFFECTS OF CARBARYL ON *RENUVICIUS AMERICOPRUS* (GARAON) (HEMIPTERA: NABIDAE).
E. R. Mehring* and R. L. Plenkowski. Dept. of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

The goal of this research was to quantify long term effects on an insect predator after exposure to carbaryl. We collected damsel bugs from alfalfa and exposed them to carbaryl-treated surfaces for 12 hours. We used probit analysis to estimate insecticide concentrations which should produce 2% (LD_{02}) and 20% (LD_{20}) acute mortality. We exposed 100 field-collected nabids to LD_{02} (control), LD_{20} and LD_{50} , and maintained them on alfalfa bouquets with food. We used both males and females. About 40% of the nabids contained parasites. We recorded the number of days each individual lived following the exposure.

The result was a decreased longevity for nabids in the LD_{20} treatment. The mean posttreatment longevity for the control and LD_{20} groups was 27.7 days and 19.2 days. Gender and parasitism did not significantly affect this result.

EFFECT OF ROW SPACING ON INSECT POPULATIONS, USING TWELVE COMMERCIAL VARIETIES OF SOYBEAN. D. A. Morris* and J. C. Smith. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Twelve commercial varieties of soybean were used to test spacing effects on insect population levels. On June 18, 1980, each variety was planted in 24 inch and 12 inch row spacings at a population density of 150,000 plants per acre. Weekly sweep net samples demonstrated that early season insects, spotted cucumber beetle, *Diabrotica undecimpunctata howardi* (B.) and bean leaf beetle, *Ceratomia trifurcata* (F.), had varietal preferences and that population numbers were significantly higher in 24 inch spaced rows. Late season insects, green cloverworm, *Plathypena scabra* (F.) and corn earworm, *Heliothis zea* (B.), showed varietal preference, but row spacing had no significant effect on population numbers. Nabids, *Nabis* spp., showed no varietal preference, nor were they affected by row spacing. Big-eyed bugs, *Geocoris* spp., had both varietal preference and higher numbers in 24 inch spacings. Overall, when a spacing effect was observed, the 24 inch spaced rows had significantly higher insect populations.

COMPARISON OF SUPPLEMENTS TO POOR QUALITY HAY FED TO GROWING CATTLE. Isabelle Ortigue*, J. P. Fontenot, Michele Cochran* and W. H. McClure*. Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Sixty heifers and steers, weighing 185 kg to 360 kg initially, implanted with Ralgro and wintered outdoors, were allotted to five treatment groups. Each group received fescue hay ad libitum in addition to one of the following five supplements: 1) none (N), 2) deep stacked broiler litter mixed with a minimum of corn, ad libitum (L); 3) urea in liquid supplement ad libitum (U); 4) urea-liquid supplement injected in the bales (INJ) and 5) soybean meal (SBM). The daily gains of SBM, L and U groups were higher than those of the INJ and N groups ($P < .05$). Values were .31, .27, .26, .14 and .12 for cattle fed SBM, L, U, INJ and N, respectively. The ratios of daily hay consumption, dry basis, to daily gain were: 105 (N), 57 (INJ), 46 (U), 48 (L) and 27 (SBM). The ratios of daily crude protein consumed to the daily gain were: 10 (N), 8 (INJ), 6 (U), 6 (L) and 3 (SBM). The blood samples taken after an overnight fast initially and after 71 and 119 days did not show any differences in blood urea and plasma inorganic phosphorus, calcium and magnesium. Analysis of repeated samplings of injected bales showed poor distribution of the liquid in the bales.

NUTRIENT COMPOSITION AND TRUE METABOLIZABLE ENERGY VALUES OF SOME TROPICAL FEEDSTUFFS. V. Ravindran*, E. J. Korngay, L. M. Potter*, K. E. Webb, Jr. and C. H. Parsons. Dept. of Animal Science and Dept. of Poultry Science, VPI & SU, Blacksburg, Va. 24061

Three Sri Lankan feedstuffs were analyzed for their proximate composition, cell wall composition, mineral components and amino acid composition. The crude protein contents (dry basis) of cassava tuber meal (CTM), cassava leaf meal (CLM) and sesame oil meal (SOM) were 2.9, 20.2 and 35.2%, respectively. CTM contained 88.4% nitrogen-free extractives, but was poor in minerals and amino acids. SOM had a silica content of 12.2%, indicating adulteration with sand. SOM was rich in all minerals, especially Ca (2.32%), Mg (.56%), P (1.04%) and Fe (.32%). CLM contained high amounts of Zn (249 ppm) and Mn (252 ppm). True metabolizable energy (TME) of these feedstuffs for poultry were determined using 24 adult single comb White Leghorn roosters. After a 24-hour fasting, six roosters were force-fed 25 g of each of these feedstuffs. Six roosters, fasted for another 48-hour period, served as the negative controls. Excreta was collected for two consecutive 24-hour periods. A 24-hour collection period was found to be adequate for CTM and SOM, whereas a 48-hour collection period was required for roosters force-fed CLM. The mean TME values (dry basis) of CTM, CLM and SOM were determined to be 3.76, 1.82 and 2.42 kcal/g, respectively.

THE INFLUENCE OF DENSITY ON YIELD OF LOBLOLLY PINE PLANTATIONS. D. D. Reed* and H. E. Burkhardt, Biometrics Section, Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Many, if not all, published stand-level yield models indicate that maximum yield is achieved at increasingly dense stands as age increases. Density here refers to the number of stems per unit area. After examining the results from a number of spacing studies, we found that this trend is not supported by the data. The field studies seem to indicate an opposite trend; i.e., the number of stems per unit area necessary to maximize yield decreases as age increases.

One possible explanation of the differing trends between the yield models and the spacing studies may be in the method of selecting sample plots used to develop the yield models. Sample plots are often located in well stocked portions of plantations which may not be representative of the entire stand and may mask the effect of density on yield.

The density trends displayed in the spacing studies can be incorporated into yield models by selecting appropriate variables for inclusion. Using data from loblolly pine plantations, yield models were fitted with age and density terms specified to insure that yield-density relationships would conform to those found in spacing studies. These empirical fittings showed very little change in the goodness of fit (as compared to models used in the past) while exhibiting more reasonable behavior from a biological standpoint.

CONTROL OF EUROPEAN CORN BORER WITH VARIOUS INSECTICIDES.

J. E. Roberts, Sr., and Joseph L. Despins*, Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Tests were conducted in 1980 for the control of European corn borer by means of insecticides applied to the soil and to the foliage of corn. Ample populations of European corn borer were available, however, the results of these tests left much to be desired. Results of these tests will be presented.

ARE CORN ROOTWORMS AN ECONOMIC PEST OF FIELD CORN IN VIRGINIA? J. E. Roberts, Sr., and Joseph L. Despina*, Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Corn rootworm tests have been conducted in Virginia for several years. Results of these tests would indicate that corn rootworms are not really a problem in Virginia, even though, a considerable number of corn rootworm adults are present during the growing season. The results of tests conducted in 1979 and 1980 will be presented. These data indicate that the application of soil insecticides to corn indicate that the application of soil insecticides to corn in Virginia may not be a good investment if control of corn rootworms is the criteria used to measure the value of this investment.

APPARENT INSECTICIDAL RESISTANCE OF THE FACE FLY IN VIRGINIA ON BEEF CATTLE. J. E. Roberts, Sr., and Karl A. Magura*, Dept. of Entomology, Va. Polytechnic Institute and State University, Blacksburg, Va. 24061.

In previous years dust bag applications of insecticides have given 50-75% control of face flies on cattle. However, this has gradually decreased until we are now getting no control of face flies with dust bag applications of insecticides.

In 1979 Ectrin ear tags resulted in approximately 65% control of face flies on two herds of cattle on the VPI&SU Animal Science Farm. In 1980 Ectrin ear tags on these same cattle resulted in approximately 15% control of face flies. We believe this to be evidence of insecticidal tolerance or resistance.

Plans are under way to verify the validity of this thinking by means of laboratory testing.

CONTROL OF LONG NOSED CATTLE LICE WITH SUBCUTANEOUS INJECTIONS OF MK-933. J. E. Roberts, Sr., and Karl A. Magura*, Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Two separate tests were conducted in Montgomery County in the spring of 1980 for the control of long nosed cattle lice with subcutaneous injections of MK-933. These two separate tests resulted in very positive results in that the subcutaneous injections of this chemical gave absolute control of long nosed cattle lice for 42 days after the injections were applied.

AN OUTBREAK OF TWO SPECIES OF LECANIUM SCALE (HOMOPTERA: COCCIDAE) AND THEIR ASSOCIATED PREDATORS. F. B. Schultz and L. A. Parnell. Va. Truck & Ornamentals Research Station Virginia Beach, Va.

An outbreak of the oak lecanium scale, *Lecanium corni* complex, occurred in eastern Virginia in 1980 primarily on willow oaks. Examination of the scales on unsprayed trees just prior to hatch produced five predator species, four Hymenoptera and one Coleoptera. Adults of the genera *Eunotus* and *Pachyneuron* (Hymenoptera: Pteromalidae) were collected from 32% and 31% respectively from the 101 samples. In 14% of the samples, both genera were collected. Adults of the genus *Coccophagus* (Hymenoptera: Aphelinidae) were collected from 14% of the samples. Only 1 *Blastothrix* (Hymenoptera: Encyrtidae) and 3 *Chilocorus* (Coleoptera: Coccinellidae) adults were collected from the 101 samples.

The calico scale, *Lecanium cerasorum*, appeared suddenly and in very high numbers in 1980 on Zelcova trees in 3 eastern Virginia locations. The outbreak resulted in disruption of the sale of Zelcova trees from a commercial nursery. Adults of the genus *Chilocorus* were collected from the scale but no hymenopteran predators were observed with the calico scale.

Influence of early-season infestations of the tobacco flea-beetle, *Eptix hirtipennis* (Melsheimer) (Coleoptera: Chrysomelidae) on the production of flue-cured tobacco. P. J. Sentner, Southern Piedmont Center, VPI & SU, Blackstone, VA 23824.

Field-collected tobacco flea beetles were confined at five different rates (0, 5, 10, 15 and 20 beetles/plant) to individually-caged plants of flue-cured tobacco for the 2-week period immediately after transplanting. The cages were then removed and insects feeding on the foliage were controlled during the remainder of the season. Plant height and leaf area measurements were taken at various times during the season and the green weight yield was determined.

Flea beetle densities of 0, 5, 10 and 15 beetles/plant did not have significant effects on the green weight yield, but the 10 and 15 beetles/plant rates had yield reductions of 8 and 12%, respectively. Tobacco infested with 20 beetles/plant had a 43% reduction in yield; reductions in leaf area of 42% for 6 weeks after transplanting, and 20 to 30% during the remainder of the season; plant height reductions of 33 to 37% for 6 weeks after transplanting, 24 to 27% for 7 to 8 weeks after transplanting and 17% at the end of the season. The leaf area of the tobacco infested with 10 and 15 beetles/plant was reduced 6 to 16% for 6 weeks after transplanting, and by 3 to 10% during the remainder of the season. Tobacco infested with 5 beetles/plant was not affected.

BREED OF SIRE EFFECT ON CARCASS CHARACTERISTICS OF OFFSPRING FROM ANGUS OR HEREFORD COWS. Margo Swartzel* and T. J. Marlowe, Dept. of Animal Science, VPI&SU, Blacksburg, Va.

Four sire breeds, Angus (A), Hereford (H), Simmental (S) and Charolais (C) bred to A or H cows in 6 calf crop years produced 37 AA and 120 HH straightbred controls with 42 SxH and 84 CxH crossbred male calves for carcass evaluation. Stat model included birth year, sire breed, season of slaughter, sex, yr x sex, yr x sire, sire x sex, lin and quad reg of dam's age, lin reg on slaughter age and slaughter weight. Yr, sire, sex and slaughter age were significant for all variables except ribeye NS for yr.

Brd	Sex	Live		Carc		Ribeye		Back		Marb	Percent
		wt.	fat	wt.	fat	wt.	fat	wt.	fat		
AXA	25	12	968	541	11.78	.23	4.24	52.78			
HxH	75	45	936	505	11.10	.17	3.57	52.98			
SxH	23	19	1077	589	12.29	.13	3.31	53.38			
CxH	51	33	1077	598	12.73	.16	3.28	53.49			

Linear comparisons show large breeds sig (P < .01) advantage for live weight, carcass weight, ribeye and % yield with small breeds sig (P < .01) adv for back fat and marbling. Angus sig higher than Hereford (P < .01) for carcass weight, back fat and marbling. No significant differences between Simmental and Charolais.

POST-HARVEST CHEMICAL CONTROL OF *PENICILLIUM* BLUE MOLD OF APPLE. B. L. Tepper* and K. S. Yoder, Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, VA 24061 and Winchester, VA 22601

Apples of six cultivars treated with a commercial fungicide schedule throughout the growing season were selected for uniform size and ripeness, randomized into 3 20-fruit replicates, punctured and inoculated with a 3 mm diam. dowel rod, dipped into a conidial suspension of benomyl-sensitive *Penicillium expansum* [1.3×10^5 conidia/ml]. At intervals of 4 or 24 hours after inoculation, the apples were dipped for 30 seconds in their respective fungicide treatments. Fruit was then stored for either one week at 18°C or 11 weeks at 0.5°C before decay incidence was rated.

Vangard (CCA 64251, 3.8 mg ai/L) resulted in 20% infection, but Vangard (7.5 mg ai/L) permitted only 2% rot. The standard fungicide applications of benomyl (Benlate, 300 mg ai/L), and a captan + benomyl mixture (600 mg + 300 mg ai/L) resulted in levels of control equal to that of Vangard (7.5 mg ai/L). Bitertanol (Baycor, 900 mg ai/L) allowed 62% decay. Fungicide treatments 4 hours after inoculation gave better rot control than treatments applied 24 hr after inoculation. Vangard, benomyl, and captan + benomyl all gave effective rot control for the 11-week storage period.

LD₅₀'s (mg ai/L) for germination of *P. expansum* conidia on glass slides were, respectively: captan + benomyl, 0.07 + 0.07; benomyl, 0.10; Vangard, 0.25; captan, 1.04; and bitertanol, 3.98.

EVALUATION OF RACING PERFORMANCE IN STANDARDIZED HORSES.

E. A. Tolley, D. R. Nottter and T. J. Marlowe, Dept. of Animal Science, VPI&SU, Blacksburg, VA 24061

Official racing records from the U.S. Trotting Assoc. for 2- and 3-year-old trotters at Blue Bonnets, Montreal, Canada, were analyzed to determine the effects of the following variables on horse's time at finish for mile races.

LEAST-SQUARES ESTIMATES AND STANDARD ERRORS

FOR RACING TIME IN SECONDS			
Effect	2-year-olds	3-year-olds	
Overall mean	132.01 ± .34	129.30 ± .33	
Sex			
Stallions	131.81 ± .75	129.53 ± .58	
Mares	132.22 ± .85	129.25 ± .64	
Geldings	-	129.13 ± .73	
Post position			
1	132.04 ± .50	128.96 ± .37	
2	132.42 ± .52	129.50 ± .37	
3	132.14 ± .54	129.43 ± .36	
4	131.84 ± .57	129.36 ± .36	
5	132.02 ± .52	129.06 ± .36	
6	131.55 ± .52	129.30 ± .38	
7a	132.08 ± .49	129.59 ± .37	
7b	-	129.22 ± .36	
Breaking code			
Not breaking stride	130.81 ± .39	128.02 ± .32	
Breaking stride	133.20 ± .47	130.58 ± .37	

a Includes post positions 7 and above for 2-year-olds.

b Includes post positions 8 and above for 3-year-olds.

A METHOD OF OPTIMIZING SIMULATED PRODUCTION IN LOBLOLLY PINE PLANTATIONS. Steven A. Walker* and Harold E. Burkhardt, Biometrics Section, Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Methods for determining optimal management strategies were developed using a loblolly pine stand simulation model. A constrained flexible polyhedron search was used to maximize the simulated volume and dry weight. When this method failed, a second optimization technique, response surface analysis, was used.

The stand simulator for loblolly pine plantations (PTAEDAS) was used to generate yield responses for various site indexes, initial density, and thinning conditions. The results show that at the lower site indexes (50 and 60), the flexible polyhedron search was sufficient to find an optimum for both dry weight and volume, while at site index 70 the response surface technique was required.

POST-HARVEST CHEMICAL CONTROL OF BROWN ROT AND RHIZOPUS ROT OF PEACH AND NECTARINE.

B. L. Tepper* and K. S. Yoder, Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, VA 24061 and Winchester, VA 22601

Fruit treated with a captan-benomyl program were harvested 5-7 days after the last spray, selected for uniform size and ripeness, punctured to a depth of 3.2 mm with a 3.2 mm diam. nail, and placed into plastic containers (20 fruit/container). Fruit were inoculated by dipping in conidial suspensions of *Monilia fructicola* or *Rhizopus* sp. for 30 seconds. Three hours after inoculation, the fruit were dipped for 30 seconds in fungicide suspensions and allowed to dry. The fruit containers were placed into polyethylene bags for 5 days storage at 16-22°C before evaluating decay incidence.

Brown rot incidence was greater on nectarines than on peaches. Diclolan (Botran, 900 mg ai/L) did not adequately control brown rot on either fruit. Benomyl (Benlate, 300 mg ai/L), Vangard (CCA 64251, 15 mg ai/L), and iprodione (Rovral 600 mg ai/L) provided good brown rot control on peaches. On nectarines benomyl (300 mg ai/L), Vangard (15 mg ai/L) and iprodione (1.2 g ai/L) gave significant control of brown rot when compared to the untreated and inoculated control.

Rhizopus rot was reduced by diclolan (900 mg ai/L), diclolan + benomyl mixture (900 mg + 300 mg ai/L), and iprodione (1.2 g ai/L), but none gave commercial control. Vangard and benomyl did not adequately prevent Rhizopus rot. No phytotoxic effects by the chemical treatments were observed.

ENSILING CHARACTERISTICS OF STOCKPILE TALL FESCUE.

R.A. Torres*, J.P. Fontenot, K. E. Webb, Jr., F. S. McLaugherty*, R.E. Blaser and V. Allen*. Dept. of Animal Science, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061.

A study was conducted to determine the effect of time of harvesting, wilting and addition of ground corn grain (5%) dry molasses (5%) and fornic acid (.3%) on the fermentation characteristics of stockpiled Kentucky-31 tall fescue. The fescue was stockpiled beginning in August and was harvested and ensiled in October and November. At the October harvest forage was ensiled directly and after wilting, and in November the forage was ensiled without wilting. Water soluble carbohydrate content of the October forage was 18.7% for the forage ensiled directly and 17.3%, dry basis, for the wilted forage. The value was 18.1% for the November forage. All silages had desirable appearance and aroma. Average pH values were 5.1 and 5.6 for October silages ensiled directly and after wilting, respectively, and 5.2 for the ensiled November forage (P<.05). Lactic acid content followed similar trends, with respective values of 3.8, 2.1 and 3.0%, dry basis. Average pH values for fescue ensiled alone and with added formic acid, corn and molasses were 5.4, 5.5, 5.1 and 5.2, respectively (P<.05). Respective values for lactic acid content were 3.0, 1.6, 4.1 and 3.3%, dry basis (P<.05). No advantage of wilting was observed.

ZINC, MANGANESE AND IRON CONCENTRATIONS IN APPLE LEAF SAMPLES TREATED WITH ZINEB, MANCOZEBO, AND FERRAM FUNGICIDES. K. S. Yoder and S. J. Donohue, Dept. of Plant Pathology and Physiology, VPI & SU Fruit Research Laboratory, Winchester, VA 22601 and Dept. of Agronomy, VPI & SU, Blacksburg, VA 24061

The fungicides benomyl (Benlate 50W), ferbam (Carbamate 76W), mancozeb (Dikar 76-7W, 72% mancozeb) and zineb (Zineb 75W) were applied at recommended rates with a high pressure single-nozzle handgun to mature 'Delicious' apple trees in a randomized block design with three single-tree plots. Leaf samples were collected from the mid-portions of terminal shoots 0, 4, 7, 14 and 21 days after the final application of the season. Element analysis was determined by atomic absorption spectrophotometry according to standardized procedures by the VPI & SU Soil and Plant Analysis Lab.

The ferbam treatment caused a 2-3X increase in Fe concentration over that of non-ferbam treated leaves. The mancozeb treatment gave a 4-5X increase in Mn. Zn content of zineb-treated leaves was 10-20X that of leaves from other treatments. Differences between concentrations of Fe, Mn and Zn in treated and non-treated samples were still evident 21 days after treatment although significant declines in Fe and Mn on treated foliage occurred over this period. Differences in Fe, Mn and Zn content of treated and non-treated leaves were also apparent following a tap-water rinse of a duplicate leaf sample.

BLISTER SPOT OF 'MUTSU' APPLES IN VIRGINIA. K. S. Yoder, G. H. Lacy and B. L. Tepper*, Dept. of Plant Pathology and Physiology, VPI & SU Fruit Research Laboratory, Winchester, VA 22601 and Blacksburg, VA 24061.

Symptoms resembling those of blister spot, a bacterial disease capable of reducing the fruit quality of 'Mutsu' apple were first observed in Virginia in Rappahannock County in 1980. An average of 31% of the fruit showed symptoms in the affected orchard with 8% downgrading in quality according to USDA grade standards. A bacterium was isolated repetitively from fruit lesions. By their reaction in standard bacteria identification tests (agar fluorescence, gel liquefaction, hypersensitivity on Burley 21 tobacco arginine dihydrolase, oxidase, and lactate utilization), these isolates resemble isolates of *Pseudomonas syringae* pv. *papulans*, the blister spot pathogen, from New York and Ontario. Confirmation of the identity of the Virginia isolates awaits proof of pathogenicity through inoculation studies on apple.

A COMPARISON OF SAMPLE DATA TYPES IN QUANTIFYING DIAMETER DISTRIBUTIONS WITH THE WEIBULL FUNCTION. B. R. Zutter*, and R. G. Oderwald*. Biometrics Section, Dept. of Forestry, VPI & SU, Blacksburg, VA 24061.

A simulation study was undertaken to determine whether censored and/or truncated sample data might be used in lieu of complete data in quantifying diameter distributions with the Weibull function. Three levels of intensity of censoring and truncation were examined to determine whether intensity had an effect on distribution quantification.

Monte Carlo simulation was used to generate samples from a 2 parameter complete Weibull distribution. Twenty-five parameter combinations were used in data generation, covering the range of combinations encountered when fitting data from even and uneven-aged stands. For each sample the parameters of a 2 parameter complete Weibull were found using the method of maximum-likelihood. Comparisons among the sample data types were made based upon statistics computed for each fit distribution.

Based upon the comparison criteria, truncated data were judged to be unsuitable for quantification of complete diameter distributions. Distribution quantification using censored data at the two lowest levels of censoring was nearly as good as using complete data. It was concluded that the collection of censored data may be an alternative to complete data depending upon the results of field studies and the desired level of precision set by the forest manager.

Astronomy, Mathematics, and Physics

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

A FREQUENCY-MODULATED COIL SENSOR FOR MAGNETIC SUSPENSIONS. Bruce E. Bernard*, W. Stephen Cheung*, and Rogers C. Ritter† Dept. of Physics, University of Virginia, Charlottesville, Va. 22901.

A frequency modulated (FM) coil sensor using digital electronics is described here for use as a position transducer in a magnetic suspension. This is similar to the Q-coil method of Beams used in magnetic suspensions except that a different parameter, the oscillation frequency, is being controlled. The change in resonant frequency of an LC tank circuit as the suspended object moves is the basic signal. The frequency of the LC tank circuit is mixed with a stable frequency standard and the output of the mixer is converted into a voltage by a frequency to voltage converter. This voltage constitutes the control signal and with appropriate gain and electronic damping is used to suspend the object. Two advantages of this FM suspension circuit are that the control signal is independent of the amplitude of the LC tank circuit and is less sensitive to changes in temperature than the Q-coil method of suspension. Supported by NSF Grant PHY80-07948 and NBS Grant G8-9025.

CURRENT STATUS OF THE INERTIAL CLOCK EXPERIMENT.

W. Stephen Cheung* and Rogers C. Ritter†, Department of Physics, University of Virginia, Charlottesville, Virginia 22901.

An ultra high Q inertial clock was proposed to test non-metricity of gravity¹. It involves two corotating rotors, doubly magnetically suspended along their rotating axis, with the upper rotor providing protection to and also made to follow the lower rotor which is the inertial time keeper. Parametric optical transducers employing synchronous detection and the phase locked loop method for suspensions with enhanced stability and noise immunity were reported. Recent development involves a hybrid double suspension with optical and frequency-modulation coil² sensors for the upper and the lower suspension respectively. Our apparatus for the Snyder algorithm³ to measure the rotors' rotational periods is also near completion. This algorithm permits significantly less experiment time for acquiring the desired precisions.

Apparatus for the clock experiment will be illustrated. This research is supported by NSF Grant PHY80-07948 and NBS Grant G8-9025.

1. W. S. Cheung and R. C. Ritter, Virginia Academy of Science meeting, 1980.
2. B. E. Bernard, et al., Virginia Academy of Science meeting, 1981.
3. J. Snyder, NBS, private communication.

INFRARED SPECTRA OF ASYMMETRIC TOPS. G.E. Copeland and P.M. Fazio, Dept. of Physics, Old Dominion University, Norfolk, VA 23508

The method of calculation of line positions and strengths for asymmetric rotors is described. Rigid rotor matrix elements are calculated in the symmetric rotor representation $|J_K M\rangle$ and then diagonalized to yield the rotational energy levels (E_J). Eigenvectors so obtained $|J_r M\rangle$ are used to calculate dipole derivative matrix elements. Selection rules for a, b and c type transitions, together with population factors, are implemented to calculate the vib-rotational infrared spectra for any molecule. Improvements to introduce non-rigid behavior are described.

SUPERCONDUCTING ELECTRONICS. Bascom S. Deaver, Jr. Dept. of Physics, University of Virginia, Charlottesville, VA 22901.

Superconducting devices have emerged from the research laboratory and are now being used in electronic systems providing heretofore unattainable levels of precision, speed, sensitivity and low loss. Devices based on the Josephson effects and fluxoid quantization make possible amplifiers and detectors that approach quantum noise limits and digital devices with picosecond switching times. Together with integrated circuit technology these devices are being used for instruments and digital systems that extend by several orders of magnitude the sensitivity available for magnetic measurements and make possible computers 10-100 times faster than the best present ones.

DYNAMIC VISIOPLASTICITY - A NEW APPROACH IN PLASTICITY. S. M. Dwivedi^{*}, Dept. of Physics, Old Dominion Univ., Norfolk, VA

The viscoplasticity was introduced by Thomsen and later developed by the author. In this method, the grid line patterns are photographed for each incremental step of deformation and thus the movement of grid points can be determined. From enlarged photographs of consecutive grid patterns the instantaneous velocities of all grid node across the surfaces can be found. The strains, strain rates, total effective strain can thus be determined for all points in the deformation region and finally the stress field and forming loads may be found.

In this method the instantaneous flow field is an actual one and gives information of all strains and stresses over the entire deformation region. It may be used for both workhardening and non-workhardening materials.

CONTINUING EDUCATION: NEEDS OF PHYSICISTS AND NEEDS IN PHYSICS. R. Ehrlich^{*}, W. M. Black^{*}, Physics Department, George Mason Univ., Fairfax, VA 22030

We have conducted two recent surveys of physicists and engineers in the Greater Washington D.C. area to assess their continuing education needs. Respondents to the physics survey appear to have a number of similarities to the respondents in a recent AIP national survey, and hence their views on continuing education and their needs for specific topics may well be of general interest. Despite the fact that 74% of the physicists surveyed already hold the Ph.D. they continue to have strong needs for continuing education, with the need more in engineering than physics.

The survey of engineers is also of interest since our concern here encompasses both the continuing education needs of physicists as well as the continuing education needs of anyone who may be interested in physics. The surveys include several novel elements in terms of methodology, and should be of interest to anyone attempting to assess regional continuing education needs in any discipline.

SUPERCONDUCTIVITY OF SMALL Pb PARTICLES PRODUCED BY CHEMICAL TECHNIQUES. T.L. Fariss^{*}, W.E. Nixon^{*}, B.S. Deaver, Jr. and J.W. Mitchell, Dept. of Physics, Univ. of Virginia, Charlottesville, VA 22901.

Chemical techniques are being developed for producing small superconducting particles and microstructures in an insulating medium. The techniques give good control of particle size and shape and a very small spread in particle size can be obtained so that size can be a controlled variable in studying particle properties. Particles with mean dimensions from 1 μm to less than 10 nm are being produced. The particles are characterized by optical and electron microscopy and electron diffraction, and the superconductivity is being studied by measurements of the magnetization as a function of temperature and magnetic field.

Research supported by NSF Grant No. DMR78-25791

SURFACE CRITICAL PHENOMENA. Carl P. Franch^{*} and Stephen E. Schnatterly^{*}, Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

We are studying the critical demixing transition of carbon disulfide and nitromethane in the vicinity of a glass wall which preferentially adsorbs nitromethane. By measuring the reflectivity of the fluid/glass interface as a function of temperature, we are testing theories of surface critical phenomena. For example, it has been suggested by de Gennes and Fisher¹ that a wall layer with a thickness on the order of a correlation length should appear in such a system.

¹ C.R. Acad. Sc. Paris, t.287 (1978), Série B - 207.

THEORY OF GROUP PERIPHERIES. Richard I. Gomberg, NASA Langley Research Center, Hampton, VA 23665.

Let G be a group and H a subgroup of G . Then $P_G(H) = \{G \cdot H\}$. The properties of $P_G(H)$, called the periphery of H in G , are based on two fundamental lemmas.

- (i) If $h \in H$, and $peP_G(H)$, then $hpeP_G(H)$.
- (ii) h can always be expressed as the product of two elements $P_G(H)$.

Applications are made to Abelian Groups, Sylow Groups, Solvable Groups, Isomorphisms, and Permutations.

SCATTERING OF LIGHT FROM ROUGH SURFACES. M. Haller^{*}, V. Celli and A. Marvin^{*}, Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

The scattering at electromagnetic waves provides a useful tool in studying rough metal surfaces. The surface roughness couples the incident radiation to the surface plasmon oscillations (SPO) causing excitation of these modes. These surface plasmon oscillations may then diffract through the surface roughness into other SPO modes or they may decay back into the continuum. The depolarization of the incident light and the intensity maxima at certain scattering angles may be attributed to these processes.

MOSSBAUER STUDIES OF IRON SPIN DYNAMICS. G.R. Hoy, Dept. of Physics, Old Dominion University, Norfolk, VA 23508.

Mossbauer spectra of substances which magnetically order often show a central peak with prominent wings in the region of the ordering temperature. While commonly attributed to the co-existence of paramagnetic and ordered components, we will show that these "anomalous" spectra can arise from atom spin fluctuations on a time scale of 10^{-11} sec. Recently developed theoretical techniques allow the effects of such dynamic processes on Mossbauer spectra to be calculated. The resulting analysis can yield information about: the atomic Hamiltonian, the nature of the hyperfine interaction, the magnetic ordering, the origin of the dynamic process, and the spin fluctuation rate. We will present model calculations for Kramers' ($S = 1/2$) and non-Kramers' ($S = 1$) salts. The characteristic differences between the two cases will be emphasized, and the dependence of these spectra on: the spin Hamiltonian parameters (D , E), the reduced magnetization, and the spin fluctuation rate will be examined. In particular, we will investigate the region near the ordering temperature to show the effects on the spectra of short range order and critical slowing down of the spin fluctuation rate.

ENERGY LOSS OF SWIFT DIATOMIC NITROGEN IONS IN CARBON FOILS.^{***} E. A. Johnson,^{*1} D. S. Gemmell,^{*} E. P. Kanter,^{*} M. F. Steuer,^{**2} and B. J. Zabransky.^{*} Physics Division, Argonne National Laboratory, Argonne, Ill. 60439.

Soon after a fast (MeV) diatomic ion penetrates the surface of a foil, collisions with target electrons strip away the ion's binding electrons, leaving two charged fragments. The correlated motion of these fragments, due to their mutual electrostatic repulsion, influences the measured energy loss of the fragments.

This note describes recent energy loss experiments by Argonne's molecular ion beam group and presents several calculations involved in the analysis of experimental results.

^{***}Work supported by Office of Basic Energy Sciences, U. S. Department of Energy.

¹Undergraduate research participant from Washington and Lee University, Lexington, Va.

²On leave from University of Georgia, Athens, Ga.

DECAY TIME STUDIES OF MAGNETICALLY SUSPENDED ROTORS.

G. R. Jones, Jr.,^{*} and R. C. Ritter.^{*} Physics Department, University of Virginia, Charlottesville, Virginia 22901.

Decay time studies have been performed on four rotors with masses of approximately 250 gm and support slugs of different shapes and materials at frequencies from 0 to 8 Hz. For supporting the rotors a split-photodiode, optically sensed magnetic suspension was used. All of the rotors exhibited decay time values at least an order of magnitude below the values predicted by the gas friction rule, thus suggesting that anomalous drag mechanisms are in effect. Further, the spectra of decay time versus rotational frequency exhibited properties which suggest some type of mode coupling and/or interaction between the rotor and the support. Additional studies further implicated the support as a probable source of anomalous torques. This research is supported by NSF Grant PHY80-07948 and NBS Grant G8-9025.

THE UNSTABLE MIXED LAYER AS A SOURCE OF DOWNWARD PROPAGATING NEAR-INERTIAL MOTION. John Kroll, Dept. of Math. Sciences, Old Dominion University, Norfolk, VA 23508

The stability of a one layer turbulent slab model of the mixed layer over a continuously stratified, inviscid, semi-infinite ocean is investigated for large scale (200 km) perturbations. We assume the steady state values for the velocity, density and depth of the mixed layer are essentially uniform in time and space and use eddy viscosity. The model is crude, but the results are interesting. A critical point for instability is found at which the frequency in most cases should be only slightly greater than the local inertial frequency. This implies that the Ekman transport could be a source of downward propagating inertial motion and can be produced without wind curl. Also the downward propagating inertial motion could be an important energy sink for the mixed layer and limit its depth.

POWER MEASUREMENTS FOR NON-SINUSOIDAL A.C. WAVEFORMS. M.C. Kruttsch*, M.S. Eaton*, F.P. Clay, Jr. Dept. of Physics, Old Dominion University, Norfolk, Va. 23508.

Standard power meters used for the sale of electric energy to customers are usually calibrated with sinusoidal voltage excitation in a circuit yielding a sinusoidal current response. A measurement of the energy used, from a measurement of the true RMS voltage and the current response shows a significant difference between the "metered" kWh's and the energy actually supplied in a circuit containing rectified currents. The existence of a difference between the metered energy and the actual energy used may be a significant economic consideration for electric power installations containing rectifiers, SCR's, etc.

KNIGHT SHIFTS IN AMORPHOUS VAl AND VSi ALLOYS. L. Mattix and H. E. Schone, Dept. of Physics, College of William & Mary, Williamsburg, VA 23185.

Amorphous alloys of VAl (15 to 85 at. % Al) and VSi (5 to 25 at. % Si) have been prepared by r.f. sputtering onto substrates held at 77°K. The V_{51} nuclear magnetic resonance Knight shifts have been determined as a function of Al or Si concentration and of temperature.

Our results in amorphous VAl show no temperature dependence. The V_{51} Knight shifts increase linearly with increasing Al concentration, and agree with the results of crystalline alloy studies.

In amorphous VSi, we see no temperature dependence in the V_{51} shift even at the stoichiometric composition of the A-15 compound V_3Si , which exhibits a very strong temperature dependence in the V_{51} Knight shift. A temperature dependence is seen in annealed VSi, probably due to the appearance of V_3Si upon crystallization. This has been confirmed by x-ray diffraction.

We conclude that the major features of the density of states curve near the Fermi level depend only on short range order, and that this local order is the same for both the amorphous and the crystalline alloys. The case of V_3Si is an exception. The strong temperature dependence is due to the presence of a sharp feature in the density of states curve near the Fermi level which is peculiar to the A-15 structure. It is not surprising that this feature and the resulting temperature dependence is not seen in the amorphous phase.

THE NEW MAGNETIC MONOPOLES: SOME SPECULATIONS ON WHERE TO SEARCH. Stanislaw Mikocki and W. Peter Trower, Dept. of Physics, VA Tech, Blacksburg, VA 24061.

The failure to detect Dirac magnetic monopoles during the half century since their prediction is reviewed in the context of current grand unification theories. Specific experiments are proposed to search for monopoles with these augmented properties.

PARTICLE BEAMS AND PULSE STRETCHERS. Blaine Norum^{*}, Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

Accelerators capable of delivering pulsed beams of charged particles for use in nuclear physics studies have been in operation for decades. However, many of the most promising experiments require continuous rather than pulsed beams. One method of generating such beams which utilizes the well understood technology of pulsed accelerators is to combine a standard pulsed accelerator with a "pulse stretcher ring". Each short pulse from the accelerator is stored in the ring and then extracted slowly during the interval before the next pulse arrives. Such a composite device has been proposed by the Southeastern Universities Research Association (SURA) for the generation of continuous beams of electrons with energies up to a few GeV.

RELATIVISTIC HEAVY-ION FRAGMENTATION BY ABRASION: DELTA FUNCTION INTERACTION. L. W. Townsend,* NASA Langley Research Center, Hampton, VA 23665

A zero-range (delta function) optical model potential approximation to the nucleus-nucleus multiple-scattering series is used in an abrasion-ablation collision formalism to predict cross sections for the fragmentation, by abrasion, of relativistic projectile nuclei in collisions with heavy target nuclei. General expressions for the abrasion cross sections will be developed and applied to specific projectile-target combinations for several different nuclear single-particle density distributions. For the Woods-Saxon distribution, comparisons between results obtained for zero-range and for finite-range interactions will be made. Comparisons with recent experimental results and with predictions from other theoretical models will also be presented.

THE PROTON HALO. W. Peter Trower, Dept. of Physics, VA Tech, Blacksburg, VA 24061.

In 1968 several fundamental experimental and theoretical results which were in conflict could be explained if the proton had a halo consisting of a few percent of its charge deployed at several fermis. We attempted an experiment to directly measure this halo which has recently succeeded. The nature of the motivating discrepancies and their eventual resolution are discussed as well as the current prospects for the halo in light of our data.

THE GEOMETRY OF SOAP BUBBLE CONFIGURATIONS. Peggy R. Wright, Lake Braddock Secondary School, Fairfax Co., VA.

This research was undertaken to describe and demonstrate the relationships between several factors governing the geometry of soap bubble configurations. Bubbles of different radii were formed and observed in groups and accurate measurements were taken of the angles of interaction. The previous work of Plateau was verified and extended by mathematical investigation of the data. This showed that internal pressure must be the primary force in the interactions between soap bubble surfaces.

Biology

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

A COMPARISON OF THREE PHOTOMETERS FOR READING ENZYME-IMMUNOASSAYS PERFORMED IN MICROTITER PLATES. Steven B. Ackerman, Patti M. Mason, J. E. John and P. J. Adams, Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508

A popular novel serologic technique, enzyme immunoassay, is most often performed in clear plastic microtiter plates. The final step in this assay produces a color shift, which can be spectrophotometrically quantitated. The performance of a fiber optic probe colorimeter (Model 800, Brinkmann Instruments, Inc.) was compared to a spectrophotometer (Beckman Instruments, Inc.) and an ELISA-reader (Model MR 590, Dynatech Instruments, Inc.). We used as a chromophore source alkaline phosphatase/ p-nitrophenyl phosphate in 3N NaOH. Reproducibility values (100% - coefficient of variation) were 99.2% for the probe colorimeter, 99.1% for the spectrophotometer and 99.1% for the ELISA-reader, when one individual read the same sample at least 20 times in each instrument. Reproducibility for the colorimeter ranged between 96.4-97.2% when five individuals each performed 24 independent measurements. One way analyses of variances for mean absorbance values determined for 88 measurements indicated no significant differences between performances of the three instruments. However, the probe colorimeter did not demonstrate linear regression functions when absorbance values of a dilution series of chromophore was analyzed by least-square analysis. Advantages and disadvantages of each instrument for reading the enzyme immunoassay will be discussed.

THREE FORMS OF ENZYME-IMMUNOASSAYS FOR DETECTION OF ANTI-SPERM ANTIBODIES. Steven B. Ackerman, Patti M. Mason, Stephen Keefe and Debra Martin. Dept. of Biology, Old Dominion University, Norfolk, Va. 23508.

Recently, we reported an enzyme-linked immunosorbent assay (ELISA) to detect antibodies to human sperm (Ackerman et al., 1981, Amer. J. Reprod. Immun., Vol. 1). In this current study several variations of this assay were examined. Sperm were employed in this assay as (a) intact cells adsorbed to microtiter wells, (b) intact cells in suspension, or (c) soluble extracts (saline and detergent) or saline-insoluble cell components adsorbed to microtiter plates. Several methods of serum incubation and antigen washing procedures were also investigated for usefulness in this assay. Preliminary results suggest that maximal reaction intensities were obtained when freshly obtained sperm were used as intact cells in suspension. However, absorption of whole sperm or sperm fractions onto polystyrene microtiter plates was more convenient, since the need for fresh sperm each time the assay was performed was avoided.

AN ENZYME-LINKED IMMUNOASSAY FOR QUANTITATING ANTIBODIES TO HUMAN SPERM: COMPARISON WITH OTHER IMMUNOASSAYS. Steven B. Ackerman, J. W. E. Wortham and R. James Swanson. Andrology Laboratory, Dept. of Biology, Old Dominion University, Norfolk, Va. 23508.

An enzyme-linked immunosorbent assay (ELISA) was devised to measure antibodies to human sperm. Details of the procedural parameters and the reproducibility tests of this assay will be presented. Comparing ELISA with other commonly-performed antisperm assays, titers of rabbit antisperm sera, as measured by ELISA, Kibrick macroagglutination, Franklin and Dukes microagglutination, and Isojima immobilization, were 1/16, 384, 1/32, 1/64 and 1/256, respectively. Results of our studies indicate that ELISA for detection of antisperm antibodies overcomes many of the problems associated with agglutination, immobilization, cytotoxicity and penetration assays: (a) no need to routinely obtain and maintain viable, motile sperm; (b) results are obtained objectively and rapidly, without the need for laborious microscopic evaluation by trained personnel; (c) by using enzyme-conjugates specific for individual immunoglobulin classes and/or sub-classes one can obtain in-depth knowledge as to the type of antibody responsible for antisperm activity; and (d) following determination of base-line values for clinically significant levels of antisperm antibodies, reagents may be diluted and procedures modified so that a qualitative assay is devised, which may be performed in the clinician office.

ORGAN WEIGHTS OF RIVER OTTERS. Karen Lynn Anderson, and Patrick F. Scanlon. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

During the 1979-1980 trapping season, carcasses of 244 river otters, *Lutra canadensis*, from throughout the eastern portion of the state were obtained from trappers. Kidneys, adrenal glands, liver, heart, and spleen were removed from each otter and weighed to the nearest 0.01g. The mean weights (g \pm S.E.) of each tissue was as follows: left kidney, 45.71 \pm 0.77; right kidney, 47.01 \pm 0.88; both kidneys, 92.54 \pm 1.55; left adrenal, 0.50 \pm 0.01; right adrenal, 0.45 \pm 0.01; both adrenals, 0.95 \pm 0.02; spleen, 60.36 \pm 1.36; heart, 63.91 \pm 1.60; and liver, 334.90 \pm 6.23. Significant ($P < 0.05$) differences occurred between sexes in mean weight of left kidneys, right kidneys, paired kidneys, spleens and livers. Among females, no significant differences were found between mean weight of left and right adrenals or left and right kidneys. A significant difference was found between mean weight of left and right adrenals of males.

<p>REPRODUCTION AND POPULATION CHARACTERISTICS OF RIVER OTTERS IN VIRGINIA. Karen Lynn Anderson and Patrick F. Scanlon. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.</p> <p>During the 1979-1980 trapping season, carcasses of 244 river otters, <i>Lutra canadensis</i>, from throughout the eastern portion of Virginia were obtained from trappers. Of the 244 otters, 97 were female and 147 were male. Data on reproduction was obtained by dissection and examination of the reproductive tracts. The mean number of corpora lutea in 24 oviducted females (all older than one year) was 2.5 \pm 0.089 (S.E.). The mean litter size for 8 females with pregnancies beyond the implantation stage was 2.75 \pm 0.177. Pre-implantation mortality was estimated to be 8.34%. Ages of otters were estimated by counting annuli in the cementum layer of a lower canine tooth. The trapped otters were distributed in the age classes as follows: 0-1 yrs., 20.6%; 1-2 yrs., 33.2%; 2-3 yrs., 32.2%; 3-4 yrs., 9.3%; 4-5 yrs., 4.2%; and 5-6 yrs., 0.5%. Unadjusted age specific survival rate for the 0-1 year age class was estimated to be 1.61; for 1-2 yrs., 0.972; 2-3 yrs., 0.289; 3-4 yrs., 0.450; and for 4-5 yrs., 0.111. The recruitment rate (number of female pups per adult female) was calculated to be 0.412 and the ratio of yearlings and juveniles to adult females was 2.618. The adjusted recruitment rate was 1.235. The otter population appears to be stable at the present time.</p> <p>However, repetition of this study for the 1980-1981 trapping season will provide more information on the status of the population.</p>	<p>HEAVY METAL CONCENTRATIONS IN TISSUES OF RIVER OTTERS FROM VIRGINIA. Karen L. Anderson and Patrick F. Scanlon. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.</p> <p>Liver, kidney and bone samples were taken from 244 river otter, <i>Lutra canadensis</i>, carcasses collected during the 1979-1980 trapping season in Virginia. Concentrations of lead, cadmium, copper and zinc were determined using an atomic absorption spectrophotometer in the flame mode. The maximum concentration (g/g dry tissue) of each element found in the three tissues was as follows: (liver) Pb, 55.89; Cd, 0.99; Cu, 211.00 and Zn, 235.68; (kidney) Pb, 6.60; Cd, 14.09; Cu, 80.15 and Zn, 564.34; (bone) Pb, 35.16; Cd, 0.00; Cu, 5.69; and Zn, 822.93. The mean (\pm S.E.) concentrations found in tissues were as follows: (liver) Pb, 1.40 (\pm 0.62); Cd, 0.09 (\pm 0.01); Zn, 62.23 (\pm 2.17); Cu, 13.92 (\pm 1.48); (kidney) Pb, 0.81 (\pm 0.07); Cd, 0.61 (\pm 0.09); Zn, 78.91 (\pm 4.88); Cu, 6.16 (\pm 0.59); (bone) Pb, 1.41 (\pm 0.22); Cd, 0.0; Zn, 179.13 (\pm 9.49); and Cu, 0.13 (\pm 0.04). Mean concentration of cadmium in kidney increased with age of otters indicating an accumulation of cadmium in otters as they became older.</p>
<p>HEAVY METAL CONCENTRATIONS OF TISSUES OF PINE VOLES FROM FOUR VIRGINIA ORCHARDS. Karen L. Anderson, Frederick A. Servello, and Patrick F. Scanlon. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.</p> <p>Hair (washed and unwashed) and bone samples of pine voles, <i>Microtus pinetorum</i>, trapped during late fall and winter (1980-1981) in four Virginia orchards were analyzed to determine concentrations (g/g dry weight of tissue) of lead and cadmium. Concentrations of cadmium found were below the limit of detection (0.02 μg/g) in all tissues. Mean (\pm S.E.) lead concentrations found were as follows: (orchard A) bone, 10.73 (\pm 4.42); washed hair, 1.63 (\pm 0.95); unwashed hair, 1.33 (\pm 0.43); (orchard B) \sim0.2 for all tissues; (orchard C) bone, 1.30 (\pm 0.75); washed and unwashed hair, \sim0.2; (orchard D) bone, 28.17 (\pm 6.57); washed hair, 1.47 (\pm 1.47); unwashed hair, 2.19 (\pm 1.46). Lead concentrations did not appear to increase with age.</p>	<p>MIGRATORY TIMING OF BROWN SHRIMP (<i>PENAEUS AZTECUS</i>) IN PAMlico SOUND, NORTH CAROLINA. A. M. Babcock, Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508.</p> <p>Migration of adult brown shrimp was analyzed using the time density approach. Time density refers to the probability of the migration, and is estimated as the proportion of the total population (or the proportion of an observation which is proportional to the population, e.g. catch per unit effort). This model provides a dynamic model of shrimp migration throughout the entire fishing season. Catch statistics received during 1978-80 from Pamlico Sound, the Neuse River, the Pamlico River, and Core Sound were analyzed in this study. Indications of environmental characteristics of the areas observed were reflected in the time densities. Time densities proved to be stable and homogeneous which facilitated the use of this model for estimation of total catch throughout the fishing season.</p>
<p>PERIPHONY COMMUNITY STATUS IN THE RAPPAHANNOCK RIVER SYSTEM AND BULL RUN CREEK AFTER THE MARCH 1980 OIL SPILL. M. L. Bass, Dept. of Biological Sciences, Mary Washington Coll., Fred., VA. 22401 and W. G. Landis, Franklin Research Center, Silver Spring, Md. 20910.</p> <p>On March 6, 1980 two simultaneous breaks occurred in Colonial Pipelines refined products line in Northern Virginia. One break released 8,000 barrels of kerosene into a tributary of Bull Run Creek and the other released 2,190 barrels of No. 2 fuel oil into a tributary of Mine Run Creek. Sediment samples were tested for residual oil by gas chromatography. The results were correlated with the status of the periphyton community. Periphyton was sampled directly from natural substrate in late July and early August using a bar clamp sampler. An estimate of the number of organisms/cm² at each sampling station was performed by microscopic identification and counting. Dry weight and ash-free weight analyses were performed by standard methods. Analysis of the periphyton community in the Rappahannock System 4 months post spill showed an increase in biomass at the nearest impacted station which is most likely due to increased bacteria and blue-greens with subsequent decrease in diversity and biomass followed by an increase or stabilization of these parameters at the farthest downstream stations. In Bull Run Creek 5 months post there was a decrease in biomass and diversity at the nearest impacted station with a subsequent increasing trend of these parameters downstream from the impacted area.</p>	<p>FORAGING ECOLOGY OF ANOLIS LIVIDUS, AN ENDEMIC LIZARD ON MONTSERRAT, WEST INDIES. Garnett S. Brooks, Dept. of Biology Col. of William and Mary, Williamsburg, VA. 23185.</p> <p>Adult males of <i>Anolis lividus</i> obtain a snout-vent length (SVL) of 68-70mm, weigh 8-9g, and are usually 1.5 times longer and 3.5 times heavier than adult females. This species occurs in a variety of vegetational communities (scrub to rain forest) and occupies most available structural habitats. All sizes are typical sit-and-wait predators on small invertebrates. Data on structural habitat and stomach contents were obtained for 316 individuals taken over a four month period. Large males (SVL \geq 56mm) occupied high perches, medium sized males and adult females (SVL = 41-55mm) occurred at intermediate heights, and small males and females (SVL \leq 40mm) were found mainly on the substrate or on low perches. Ants were the major prey in terms of occurrence (96%) and in numbers (72%). Other important prey were roaches, spiders, lepidopteran larvae, adult coleopterans, and heteropterans. Individuals appeared to feed throughout their activity period. The mean number of prey per lizard was 19 and the mean prey length; 2.6mm. Only 7% of the prey were 6mm or longer. Mean prey length (but not mean number of prey consumed) was positively correlated with lizard size. However, mean prey length (and mean number of prey) for males and females of seven size groupings were not significantly different. The later results are contrary to those found by Schoener (Science 155: 474-477, 1967) for the solitary species, <i>Anolis conspersus</i>.</p>

CULICOIDES SPECIES DISTRIBUTION IN THREE NEOTROPICAL LIFE ZONES (DIPTERA: CERATOPOGONIDAE). Dr. Joseph E. Broume, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Culicoides populations were sampled by light-trap collections on a regular basis for 2 years in three life zones in Colombia, South America. The species captured are grouped into abundant (>10%), common (>5 to 10%), occasional (>1 - 5%), and rare. The relative abundance of 18 species is compared from a tropical lower montane wet forest (1850 m), tropical premontane wet forest (1676 m), and a tropical dry forest (956 m).

EFFECT OF HOST DIET ON ESTABLISHMENT, GROWTH, AND MATURATION OF THE MOUSE BILE-DUCT TAPEWORM *HYMENOLEPIS MICROSTOMA* (Cestoda: Cyclophyllidae). Dr. Joseph E. Broume, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Separate groups of mice were maintained on a normal, or high protein, or high fat diet. Each mouse was infected with 8 cysticercoids of the bile duct tapeworm, *Hymenolepis microstoma* harvested from beetles of the genus *Tribolium*. At 15 days post-infection the number of worms harvested from the mice maintained on a high protein or high fat diet was significantly lower than the number from mice maintained on normal chow. The mean worm weight was significantly higher in the normal-chow mice in spite of the crowding effect due to a larger worm burden. Protein and glycogen assays of the worm tissue suggest that, unlike the cells of the vertebrate host, the worms have only limited capacity to convert fats or proteins into an energy substrate for metabolic activity.

RESPONSES OF SELECTED BLOOD CHARACTERISTICS TO NUTRITIONAL RESTRICTION IN WHITE-TAILED DEER. W.C. Gard^a, R.L. Kirkpatrick, K.E. Webb, and P.F. Scanlon. Dept. Fish and Wildlife Sciences and Animal Sciences, VPI&SU, Blacksburg, Va. 24061

This study was conducted to determine the effects of a long-term moderate nutritional restriction on selected blood characteristics in white-tailed deer (*Odocoileus virginianus*). Ten male adult deer were fed either *ad libitum* or 65 percent of the *ad libitum* energy intake on a metabolic body weight basis for 91 days beginning 24 October 1980. Following treatment, the restricted group was refed *ad libitum* for 14 days. Mean body weights for both groups combined declined 19 percent from an initial mean of 81 kg on the first day of the experiment. The restricted group maintained a 2 kg lower mean weight during treatment. This was not significantly different from the *ad libitum* group ($P>.10$). Mean serum concentrations of nonesterified fatty acids (NEFA's) differed significantly on day 7 of the experiment ($P=.08$) but not at later sampling periods ($P>.10$). Mean whole blood concentrations of β -hydroxybutyrate differed significantly on days 77 ($P=.03$) and 91 ($P=.01$) but not on earlier sampling dates ($P>.10$). No significant differences were found in concentrations of cholesterol, acetoacetate, or acetone ($P>.10$) during treatment. Following two weeks of *ad libitum* refeeding, mean concentrations of β -hydroxybutyrate for restricted animals increased 171 percent over those for the restricted period. (Supported in part by the John Lee Pratt Animal Nutrition Program).

RAT LENS GLUTATHIONE METABOLISM: IN VIVO AND IN VITRO RESPONSES OF GLUTATHIONE REDUCTASE TO SELENIUM. G. D. Clark and J. L. Hess, Dept. Biochemistry and Nutrition, VA Polytechnic Institute and State University, Blacksburg, Va. 24061

In our study of cataractogenesis we have examined lens tissue in which cataract appears 72 h following injection of Na_2SeO_3 in 9-day old rats (20 moles/kg body wt). Significant decreases in glutathione levels in lens tissue occur after 24 h. We have determined that levels of NADPH-dependent glutathione reductase, essential for maintaining reduced glutathione, decreased from 55 units/g protein at day 9 to 35 units/g protein at day 21 in control animals. Selenite injected animals retained activity at 60 units/g protein at day 21.

These differences may reflect lens weight which increases less during this 12-day interval in the selenite-treated animals. During this period, total soluble protein was 30% less in the selenite-treated animal so that the actual specific activity of glutathione reductase appeared to increase. However, glutathione reductase activity/lens was 40% greater in selenite injected animals at 12 days post-injection (age 21 days). Enzyme levels appeared not to be altered during the period of cataractogenesis (initial 72 h post-injection). Between 1 mM to 0.01 μM selenite had no effect on enzyme activity *in vitro*. The K_m for glutathione was 63 μM . (Supported by NIH grant EY01060)

MACROBENTHOS AS THERMAL STRESS INDICATORS IN WESTERN LAKE ERIE AT LOCUST POINT, OHIO. Harold N. Cones, Jr., Dept. of Biology and Env. Sci., Christopher Newport College, Newport News, Va. 23606.

Benthic macroinvertebrate collections for a three-year period from Locust Point, western basin Lake Erie, were analyzed to establish a data base to be used in determining the effects of introduced thermal effluent from the new Davis-Besse nuclear power plant. The community proved to be an Oligochaeta/Chironomid assemblage with other taxa represented by facultative or pollution-tolerant forms, indicating the presence of organic pollution at the study site. However, the study area is subject to storm- and wave-induced substrate shifting, suggesting the sampled forms may be more indicative of stress of shifting substrate than of stress of pollution. This was partially substantiated by statistical tests which showed extreme variance, with no statistical difference between stations, transects, or time. The high variance, a result of shifting substrate and of normal population dynamics, coupled with natural organic pollution at Locust Point, makes the determination of introduced thermal effluent on the population dynamics extremely difficult.

THE EFFECTS OF MELATONIN AND PHOTOPERIOD ON THE REPRODUCTIVE SYSTEM OF PINEALECTOMIZED MALE MICE, *MUS MUSCULUS*, ICR STRAIN. J.E. Constantine and F.B. Leftwich, Dept. of Biology, Univ. of Richmond, Richmond, Va. 23173.

Ninety-six male mice, age 4 wks., were obtained. Forty-eight mice were pinealectomized and 48 were sham operated. The animals were divided into 3 photoperiod regimens consisting of 1.5, 14, and 24 hr. light periods. On the 3rd to 60th post-operative days the mice were injected with 10 μg melatonin or control solution. On the 60th post-operative day, representatives of each photoperiod-surgery-injection regimen were mated with females; others were killed and several organs were removed and weighed. It was observed that organ weights of mice receiving similar injections under the same photoperiod were similar irrespective of surgery. Histological examination of testes showed normal spermatogenesis and presence of mature sperm. A reproductive study indicated that all mice were capable of producing offspring. Melatonin is shown to generally play a progonadal role but it appears that it is not mediated by the pineal in the male. Although pineal inhibition is implicated in female reproduction, the lack of effect in the male may serve to keep him in copulatory readiness at all times.

THE SEASONALITY OF OCCURRENCE OF LARVAL AND JUVENILE FISHES IN VIRGINIA'S SEASIDE ESTUARIES. James H. Cowan and Ray S. Birdsong, Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23508.

The seasonality of occurrence and relative abundance of larval and juvenile fishes from a Virginia seaside estuary was determined based on ichthyoplankton and trawl collections made from March 1979-March 1980.

The larvae of 20 species distributed among 15 families were identified from the ichthyoplankton. Larvae of the bay anchovy, *Anchoa mitchilli*, and the Atlantic silverside, *Menidia menidia*, dominated the samples and made up 57 and 34% respectively of all larvae collected. Peak occurrence began in May and continued through August. Fish larvae were present in the study area all year.

Twenty-eight species distributed among 19 families were identified from trawl collections and samples were dominated by juvenile sciaenids (6 species) which made up 68.0% of trawl collected individuals. Juvenile abundance peaked in September through December. Juvenile fishes were present in the study area all year.

Larvae and juveniles collected in this and other studies were divided in 5 ecological categories: I. Resident seaside spawners. II. Shelf spawners passively transported into the seaside estuaries. III. Post-larvae and juveniles actively seeking Virginia's seaside estuaries as nursery areas. IV. Sub-tropical intruders. V. Oligo- and Mesohaline species occasionally taken in seaside estuaries.

SOME EFFECTS OF PICNICKERS ON A GRAY SQUIRREL POPULATION. J.F. Coyle*, Dept. Fish. Wildl. Sci., Va. Polytech. Inst. and St. Univ., Blacksburg, VA 24061

A population of gray squirrels (*Sciurus carolinensis*) was studied from 26 May to 23 December in Frank Newhall Lock Memorial Park, Northampton, MA, to determine its relationship to human activity. The park was partitioned into 2 sampling strata: forested areas with picnic sites, and forested areas without picnic sites. Squirrel populations were monitored weekly using a time-area method on 6 plots in each stratum. No significant differences ($P > 0.05$) in squirrel density indices between seasons or between strata were found. A significant positive association ($P < 0.001$) between picnicker and squirrel levels was found. This may indicate that human disturbance influenced the spatial activity patterns and/or the observability of the squirrels. Feeding behavior modifications were also noted. Squirrels fed on foodstuffs left by picnickers during the summer months and returned to natural foods, such as mast, during the fall months. Leaf nests were significantly ($P < 0.05$) higher in the forested areas with picnic sites, as were the trees in which the nests were constructed ($P < 0.01$). Since large trees were located in both strata, the choice of larger trees, and therefore higher nests, could possibly be attributed to human disturbance.

EFFECTS OF LITTER SWITCHING IN *MICROTUS PINETORUM* AND FOSTER REARING OF *MICROTUS PENNSYLVANICUS* AND *PEROMYSCUS LEUCOPUS*. Jack A. Cranford, Dept. of Biology, VPI & SU, Blacksburg, VA 24060.

Maternal recognition of young is important to genetic survival, and rearing of unrelated young is maladaptive. To determine the importance of maternal recognition of offspring, litter exchanges (complete, partial, and litter increases) were carried out with *Microtus pinetorum*. Young were switched from newborn to 8 days of age and survival to weaning was determined. In complete and partial litter switches no infant mortality occurred as a function of age or type of switch made. In experiments with increased litter size, litters were generally reduced to starting size. In 7 of 23 litters, litter size returned to normal; in 3, own and strange died; in 11, strange young were weaned, while 2 litters were totally destroyed. When *Microtus pennsylvanicus* or *Peromyscus leucopus* young were added, 23-37% were reared to weaning, while 73-80% of the original *M. pinetorum* were reared to weaning. Complete and partial switches suggest maternal females do not recognize their own young, and litter size increase experiments suggest that litter size constancy is more important than litter composition. In wind tunnel tests *P. leucopus* preferentially associated with *M. pinetorum*.

EFFECTS OF PRECOCE II ON *DERMACENTOR VARIABILIS* (SAY) M. H. Dees, D. E. Sonenshine, and N. P. Buford*, Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23508.

Precoce II, a juvenile hormone antagonist, was not found to affect sex pheromone activity or accelerate molting in the American dog tick, *Dermacentor variabilis* (Say). Topical application of precoce II was fatal to engorged nymphs. The presence of adult forms in the dead nymphs indicated a generalized toxic effect rather than specific alteration of developmental processes. Results were similar when engorged nymphs were exposed to precoce II by the contact method. Topical treatment of young adult females with precoce II failed to curtail sex attractant activity. (Aided by ONR grant N-00014-80-C0546)

OYSTER SHELLS AND ARTIFICIAL TUBES: THE ROLE OF REFUGES IN STRUCTURING BENTHIC INFAUNAL COMMUNITIES. D.M. Bauer, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, VA 23508; G.H. Tourtellotte, Envir. Sci. and Engin., Inc., 4506 Hoover Blvd, Tampa, Fla. 33614; and R. M. Ewing, Barry A. Vittor & Assoc., Inc., 8100 Cottage Hill Rd., Mobile, Ala. 36609.

Clumps of dead oyster shells and glass tubes were placed in the field in January 1980 in Broad Bay, Va., in order to study the role of spatial heterogeneity in reducing the mortality of benthic infauna by epibenthic predators. In May and August 1980 samples of the macro- and meiobenthos were collected. Oyster clump treatments consisted of bottom plots covered totally with oysters or plots with clumps uniformly spaced. Samples were collected beneath and between oyster clumps. Glass tubes secured to plastic plates simulated infaunal tube densities of approximately 2,000 and 3,500 tubes per square meter. Macrofaunal densities were significantly higher in all treatments except for the total oyster coverage in May. Meiofaunal densities were usually significantly higher in all treatments except the total oyster coverage at both collection dates.

Epifaunal community development on oyster shells and the glass tubes was also studied.

THE EFFECTS OF CAFFEINE ON A NEW SPERM RECOVERY SYSTEM. Ellen DeLora J.W. Edward Worthan, Jr., Andrology Laboratory, Dept. of Biological Sciences, Old Dominion University and J. Clark Bundren* Dept. of Obstetrics and Gynecology, Eastern Virginia Medical School, Norfolk, VA 23508.

Bundren et al. recently introduced a new modified sperm-ribose technique (DISRS) to isolate a fertile sperm fraction from oligospermic semen which would be suitable for AIH. Their study showed a strong correlation between the number of quick progressive sperm in the initial sample and the total number of sperm they were able to recover. The purpose of this study was to incorporate caffeine into the DISRS technique and study its effect on sperm motility.

Equal volumes of untreated semen, phosphate-buffer treated semen and phosphate-buffer-caffeine treated semen (100 ul each) were aliquotted into microcentrifuge tubes. These were incubated at 37°C for one hour, then centrifuged at 270 xg for 5 minutes. Following centrifugation, the tubes were again incubated for 1, 2, or 3 hours. Supernatant motility was evaluated hourly according to the presence of quick progressive, sluggish progressive and non-motile sperm. These data were compared. It appears from these preliminary data that the application of caffeine may enhance the quality of the sperm fraction recovered by the DISRS technique.

COMPARISONS OF NATURAL POPULATIONS OF *DROSOPHILA MELANOGASTER* FROM VIRGINIA FOR DEGREE OF SENSITIVITY TO AFLATOXIN B₁. S. Delawar* and J.P. Chinnici, Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284

Natural populations of *Drosophila melanogaster* were collected from areas in Virginia reporting aflatoxin contamination of corn and peanut crops and from areas reporting no aflatoxin contamination. Eggs from each population sample were placed on media containing 0.0, 0.5, and 1.0 ppm aflatoxin B₁ (AFB₁). Data on egg-pupal and egg-adult development times, egg-pupal and egg-adult viability frequencies and the sex and body lengths of adults were collected to determine the relative degrees of resistance to AFB₁. Flies sensitive to AFB₁ show decreased viability, smaller adult body sizes, and significant elongation of development times. There appears to be a significant variation in resistance to AFB₁ among the populations correlating with the areas from which the flies were collected. Most of the resistant flies come from aflatoxin contaminated areas and the sensitive flies from aflatoxin free areas. Natural selection may be responsible for this correlation.

EFFECTS OF IONIC STRENGTH AND SPECIFIC IONS ACTIVITY ON THE FUNCTION OF HEMOCYANINS FROM HORSESHOE CRAB, *C. o. da C. Dieffenbach* and C. P. Mangum, Dept. of Biology, Coll. of William and Mary, Williamsburg, Va. 23185.

The respiratory properties of the hemocyanin, and oxygen carrying protein, in the blood of the horseshoe crab *Limulus polyphemus* are modified by the changes in inorganic ions that occur when the animal enters an estuary. In this study, the oxygen binding response to total salinity and to the individual ions Na⁺, Ca²⁺, Mg²⁺, Cl⁻ and SO₄²⁻ was investigated. In solutions containing only one salt, at each of three concentrations ranging upwards to the total ionic strength of native blood, oxygen affinity is very high ($P_{50} < 7$ torr at pH 7.5 and 25°C). In solutions containing virtually no inorganic ions, oxygen affinity is only slightly higher ($P_{50} = 3.4$ torr at pH 7.5 and 25°C). In solutions containing physiological concentrations of NaCl and MgCl₂, oxygen affinity is somewhat lower ($P_{50} = 8.2$ torr at pH 7.5 and 25°C), but still not as low as that of the molecule in physiological saline ($P_{50} = 14$ torr at pH 7.5 and 25°C). In solutions containing only physiological concentrations of NaCl and CaCl₂, however, oxygen affinity is almost the same ($P_{50} = 13.5$ torr at pH 7.5 and 25°C) as that of the hemocyanin in physiological saline. It is clear that the inorganic ions that are responsible for the respiratory properties of the blood are Na⁺, Ca²⁺, and Cl⁻.

EFFECTS OF FOOD RESTRICTION AND CADMIUM INGESTION ON LIVER GLYCOGEN STORES AND TISSUE WEIGHTS IN MALLARDS. Richard T. Di Giulio*, and Patrick F. Scanlon, Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

The interactive effects of cadmium (Cd) ingestion and food restriction were studied with a factorial design consisting of 2 dietary levels, ad-libitum and 60 g food/day (about 60% of ad-libitum), and 3 levels of Cd added to the food - 0, 10, and 50 µg Cd/g food. Each of 6 experimental cells contained 9 adult mallard, *Anas platyrhynchos*, drakes. The experimental diets were supplied for 6 weeks after which the ducks were sacrificed. Across all food Cd levels, restricted birds had significantly lower liver glycogen concentrations (11.8 mg/g vs. 41.6 mg/g, $P < .05$) and lower total liver glycogen (171 mg vs. 727 mg, $P < .05$) than ad-libitum birds. Restricted ducks also had significantly lower final body weights (995 g vs. 1173 g, $P < .05$), liver weights (13.5 g vs. 16.5 g, $P < .05$), kidney weights (6.2 g vs. 6.9 g, $P < .05$), and paired testis weights (18 g vs. 6.8 g, $P < .05$). The only observed effect associated with dietary Cd level was a significantly reduced ($P < .05$) average packed cell volume (PCV) in ducks consuming the 50 µg Cd/g diet (PCV = 40%) compared to birds fed the 10 µg Cd/g diet (PCV = 45%); birds eating rations with no added Cd had an average PCV of 43%. Brain weights and adrenal weights were not significantly different across all treatment groups.

EFFECTS OF PHOTOPERIOD ON GROWTH & MATURATION OF M. PINEA. Terry L. Derting and Jack A. Cranford, Dept. of Biology, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24060

The effects of photoperiod on growth and maturation of pine voles (*Microtus pinetorum*) was determined. Juveniles raised under LD8:16 had significantly greater body weights than those raised under LD16:8, beginning at 4-5 weeks of age. Additionally, juvenile females 5 weeks of age raised under LD8:16 had significantly greater uterine weights than those raised under LD12:12 and LD16:8; while females raised under LD12:12 had significantly greater ovarian weights than those raised under LD16:8. There was no significant effect of photoperiod on testes or seminal vesicle weights of juvenile males at 5 weeks of age. Adults showed the same response to photoperiod as juveniles, with adults maintained on LD8:16 being heavier than those maintained on LD12:12 or LD16:8. Adults switched from a long photoperiod (LD16:8) to a short photoperiod (12:12 or 8:16) showed increased body weights when compared to controls maintained on constant long photoperiod (LD16:8). However, there was no effect of photoperiod on litter size or frequency. In general, pine voles responded to short photoperiods by exhibiting increased body weights and juvenile females exhibited faster reproductive development.

EFFECTS OF CADMIUM INGESTION AND FOOD RESTRICTION ON ENERGY METABOLISM AND ITS ENDOCRINE CONTROL IN JAPANESE QUAIL.

Richard T. Di Giulio, Virgil E. Kopf, Patrick F. Scanlon and William C. Gwazdauskas, Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24060.

Twenty four Japanese quail, *Coturnix coturnix japonica*, were randomly assigned to a 2 x 2 factorial experiment, the factors being 50% food restriction vs. *Ad libitum* and 0 vs. 200 µg cadmium (Cd) per g of food. The addition of 200 mg/kg cadmium (Cd) to the food of quail induced a food restriction to approximately 40% of the intake of control animals (7.22 ± 0.35 g/day Cd birds vs. 17.90 ± 0.39 g/day control birds). The restricted - Cd treated birds, thus did not consume all food provided. Compared to controls, the Cd treated and restricted birds had significantly reduced body weights, liver weights and omental fat stores ($P < .05$) after 14 days. The restricted birds had significantly ($P < .05$) lower concentrations of plasma uric acid and glucose than either the control or Cd fed group. In the Cd fed birds, non-esterified fatty acids (NEFA) were significantly ($P < .05$) higher than either restricted group. Plasma triiodothyronine (T₃) values were highest in the Cd group and lowest in the restricted group with significant differences ($P < .05$) among all groups. Thyroxine (T₄) values were not different ($P > .05$) among groups. In general, the metabolic intake of the cadmium-fed quail appeared intermediate between controls and restricted birds, the latter showed typical adaptations to energy restriction.

TISSUE METAL CONCENTRATIONS IN MALLARDS FED DIETS CONTAINING CADMIUM AND/OR LEAD. Richard T. Di Giulio*, and Patrick F. Scanlon, Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Groups of 8 mallards, *Anas platyrhynchos*, were placed on one of 7 diets for 6 weeks. The diets were a commercial starter-grower ration plus: 1) no metals, 2) 10 ppm lead (Pb) in the food, 3) 100 ppm Pb, 4) 10 ppm cadmium (Cd), 5) 100 ppm Cd, 6) 5 ppm Pb and 5 ppm Cd, 7) 50 ppm Pb and 50 ppm Cd. At 6 weeks the ducks were sacrificed and dry weight concentrations of Pb, Cd, Copper (Cu), and zinc (Zn) were determined in livers, kidneys and ulnar bones by atomic absorption spectrophotometry. Mean Cd concentrations (µg/g \pm S.E.) in liver ranged from 0.9 \pm 0.1 in controls to 104.8 \pm 1.91 in the 100 ppm Cd group. Kidney Cd concentrations ranged from 2.7 \pm 0.3 in controls to 371.8 \pm 22.3 in the 100 ppm Cd group. Bone Cd concentrations were below detection limits (0.06 µg Cd/g tissue) in all groups. Liver Pb concentrations (µg/g) ranged from 0.1 \pm 0.1 in controls to 7.2 \pm 0.9 in the 100 ppm Pb groups. Kidney Pb concentrations ranged from 0.4 \pm 0.3 to 22.5 \pm 1.5, while bone Pb concentrations ranged from 0.9 \pm 0.6 to 5.3 \pm 0.8 in the same groups. Significant positive correlations between Cd and Zn concentrations in liver and kidney and between Cd and Cu concentrations in kidney may be indicative of an adaptation involving the protective function the nutrient elements Cu and Zn are thought to provide against Cd toxicity and/or may be related to metallothionein induction.

HEAVY METAL CONCENTRATIONS IN LIVERS OF WATERFOWL HARVESTED BY MARYLAND HUNTERS. Richard T. Di Giulio*, Patrick F. Scanlon, Timothy J. Dietrick*, and Vernon D. Stotts*. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Dry weight concentrations of cadmium, copper, nickel and zinc in 604 livers from 13 waterfowl species were determined by flame atomic absorption spectrophotometry. Detection limits (d.l.) for the elements assayed, μg element/g liver, dry weight, were: cadmium, 0.08; copper, 0.32; nickel, 0.4; and zinc, 0.08. Copper and zinc were present at concentrations above d.l.'s in all samples and appeared to be within normal physiological ranges. Representative values for copper concentrations in different species, Mean ($\mu\text{g/g}$) \pm S.E., N, were: Canada geese, 29.2 ± 2.0 , 159; mallards, 50.4 ± 8.7 , 114; black ducks, 34.6 ± 3.1 , 103; white-winged scoter, 40.5 ± 3.6 , 53; and oldsquaws, 20.7 ± 1.3 , 30. Zinc concentrations in these samples were: Canada geese, 158.7 ± 6.9 ; white-winged scoters, 190.9 ± 31.8 ; and oldsquaws, 168.1 ± 13.7 . The relatively high cadmium concentrations found in the livers of white-winged scoters and oldsquaws may be a function of their diets, which typically include a greater proportion of benthic invertebrates than the more herbivorous geese and puddle ducks.

A BRIEF VIEW OF THE AGE DISTRIBUTION AND RECENT REPRODUCTIVE POTENTIAL OF VIRGINIA BOBCATS. Richard B. Drinkwater*, and Burd S. McGinnes. Dept. Fisheries and Wildlife Science, Va. Polytechnic Institute and State Univ., Blacksburg, VA 24061.

The ages of 74 bobcats, *Lynx rufus*, collected between November 1979 and April 1981 were determined by analysis of tooth cementum layers. The mean age was found to be 2.82 years and the maximum age was 12.5 years. The reproductive tracts of 24 female bobcats were examined and placental scars counted. The mean litter size as judged from placental scar counts was found to be 2.33 with a minimum of 1 and a maximum of 4 scars. No evidence of breeding was found in any female less than 2 years old, based upon the absence of placental scars and corpora lutea. Females in all year classes above 2 years old showed evidence of recent breeding, the oldest being 12 years old. The sex ratio did not differ significantly from 1:1 males : females.

THE FOOD HABITS OF BEAVERS IN SOUTHEASTERN VIRGINIA. JOHN L. ECHTERNACH*, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508.

The food habits of a beaver colony in James City County, Va. were studied. Woody foods were determined by a tally of cut stumps. Some observations were made on use of herbaceous foods. Vegetation surrounding the colony was sampled using two by fifty m strip plots. Importance values were calculated for all trees, shrubs and saplings. Woody foods were given a utilization rank based on the number cut of a species and its relative density. A total of seventeen species were used as food by beaver. Of these, six species made up the bulk of the beaver diet. These were *Myrica cerifera*, *Liriodendron tulipifera*, *Cornus florida*, *Pinus virginiana* and *P. taeda* (treated as one species), *Fagus grandifolia*, and *Acer rubrum*.

THE EFFECTS OF BIOGENIC AMINES ON GASTROINTESTINAL MOTILITY IN *PERIPLANETA AMERICANA*. D. F. Edwards, R. R. Mills, and T. D. Kinsborough. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284.

A baseline of contractile effects, both in the full and empty gut from *Periplaneta americana* has been established using a standard physiological saline solution for insects. Similar intestinal contractility has been observed using *Leucorhæa maderæ* and *Gronchadorhina portensis*. This has made possible the development of a sensitive tissue marker to a number of bioactive substances being measured. Among the agents that have been tested are acetylcholine, norepinephrine, and serotonin. Preliminary results are reported.

THE HABITATS OF THE SOUTHERN BOG LEMMING, *SYNAPTOMYS COOPERI*, IN THE GREAT DISMAL SWAMP. R. K. Everton* and R. K. Rose, Dept. of Biol. Sci., ODU, Norfolk, VA 23508.

Using 0.25 hectare plots and pitfall traps, seven species of small mammals have been collected from meadow and forest habitats in the Great Dismal Swamp. Two rare endemic species (*Synaptomys cooperi helalestes* and *Sorex longirostris fisheri*) were among the three most numerous species to be collected from 10 study plots. At present *Synaptomys* and *Sorex* have been taken only in wet meadows and other non-forested habitats.

A SURVEY FOR HEARTWORM, *DIROFILARIA IMMITIS* (NEMATODA), IN DOGS FROM VIRGINIA AND NORTH CAROLINA. R.K. FALLS* and T.R. PLATT, Dept. of Biology, Univ. of Richmond, Richmond, Va. 23173.

One hundred dogs, collected from county pounds in Virginia and North Carolina, were surveyed for the presence of microfilariae of *Dirofilaria immitis* in the blood. Microscopic examination of fresh thin-films and modified Knott preparations were made. *Dirofilaria immitis* and *Dipetalonema reconditum* were found in 19% and 6% of the animals, respectively. No animals harbored both species concurrently. Prevalence was significantly higher in North Carolina (26.8%) than in Virginia (13.6%) ($p < .025$). In North Carolina, there was a higher prevalence of infection in Edgecomb and Cleveland counties than in Rowan, Davie and Gaston counties ($p < .05$). No animals in Davie and Gaston counties were infected. *Dirofilaria* was present in the four counties in Virginia; Halifax, Hanover, Henry and Mecklenburg. No significant were found between these Locales.

Mean packed cell volumes were significantly lower ($p < .0005$) in infected versus non-infected animals.

ARTHROPOD ASSOCIATES OF THE COBRA LILY (*DARLINGTONIA CALIFORNICA*). N. J. Fashing. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

The Cobra Lily, *Darlingtonia californica*, is an endangered species of pitcher plant with a patchy distribution along the Oregon coast and in the southern portion of the Cascades. A number of species of arthropods exploit this plant by living in its pitchers. Three species feed on the decomposing arthropods captured by the plant. These include the larvae of *Metricnema edwardsi* (Chironomidae, Diptera), *Megaeslia orestes* (Phoridae, Diptera) and the post-embryonic instars of *Anoetus* sp. (Histiogasteridae, Acari). The larvae of *Botanobia darlingtoniae* (Chloropidae, Diptera) are reported to do the same, but were not recorded in this study. Spiders, primarily *Erigone trilobata* (Linyphiidae), construct webs in the domes of the pitchers near the entrances and capture small insects entering the pitchers. *Proterops* sp. (Eupodiidae, Acari) utilize the protected area under the nectar roll for egg laying, and the post-embryonic instars forage on the wall of the pitcher above the water line. *Leptothrips* sp. (Eriophyidae, Acari) and *Tarsonemus* (?) sp. (Tarsonemidae, Acari) feed above the water line on the tissue of the pitcher itself. *M. orestes*, *E. trilobata*, and the four mite species are new records for this habitat, and at least two of the mite species (*Anoetus* sp. and *Leptothrips* sp.) are new. Most of the species are obligate inhabitants of the pitchers of the Cobra Lily.

FREQUENCY RESPONSE OF THE TOADFISH SWIMBLADDER. M. L. FINE*. DEPT. OF BIOLOGY, VIRGINIA COMMONWEALTH UNIV., RICHMOND, VA. 23284

Utilizing an acoustic pressure field and a vibration detector, the frequency response of the swimbladder of the oyster toadfish was measured from less than 50 to 1000 Hz. Not only was there no evidence of resonance, the swimbladder in the intact fish provided no gain over the same fish with its swimbladder filled with water. Therefore, the swimbladder does not appear to determine the frequency response of the fish's hearing or of the sounds it produces. Lack of swimbladder resonance is consistent with the temporally-based system of communication employed by the oyster toadfish.

DISRUPTION OF SEX PHEROMONE ACTIVITY IN DERMACENTOR ANDERSONI STILES AND D. VARIABILIS (SAY) BY QUINONES. D.M. Gainsburg*, D.E. Sonenshine, P.J. Homsher, and W.T. Bullard*. Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Disruption of sex pheromone activity in the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles, and the American dog tick, *D. variabilis* (Say), was achieved with injections of quinones into the female of the species. Histochemical studies, comparison of the ultrastructure, and chlorine content of the foveal glands, the site of pheromone storage, indicate changes in the cellular composition of this tissue. (Aided by NIH grant AI 10986.)

CHARACTERIZATION OF UREAPLASMA UREALYTICUM ISOLATES FROM HUMAN SEMEN. Randy Fischer, J.W. Edward Wortham, Jr., and R. D. Cinton. Andrology Laboratory, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Ureaplasma urealyticum (T-mycoplasma) has been implicated by numerous investigators as a possible etiological agent of urogenital tract disease and various instances of reproductive wastage since its isolation from patients with nongonococcal urethritis in the early 1950s. Data has been presented which suggests that alterations in specific semen parameters could be associated with the presence of *U. urealyticum* in males under examination for suspected subfertility. However, other researchers, including members of the Old Dominion University Andrology Laboratory, have conducted similar experiments and have determined that subfertile males with *U. urealyticum* in their semen do not have a decrease in semen quality when compared to those lacking this organism. This laboratory is engaged in a more comprehensive study in an attempt to determine if pathology may be related to the titer of infecting organisms and/or associated with a particular serotype. Our preliminary data suggests that titers of *U. urealyticum* range from approximately 2.0×10^4 to 4.7×10^6 CFU/ml in infected semen. Secondly, there appears to be a relationship between titer level and colony size. Thirdly, a limited number of colony characteristics will be compared between the three distinct serotypes isolated from semen in this laboratory.

CHANGES IN ADRENAL HISTOLOGY AND PLASMA ALDOSTERONE ACCOMPANYING OSMOTIC STRESS IN THE MONGOLIAN GERBIL (MERIONES UNGICULATUS). G.H. Freeman and P.B. Leftwich*. Dept. of Biology, Univ. of Richmond, VA., 23173

The Mongolian Gerbil demonstrates remarkable adaptability to osmotic stress. Not only can it tolerate the *ad lib* drinking of 6.0% NaCl, but it almost totally reabsorbs sodium in the lack of environmental sodium. It has been suggested that an atypical adrenocorticoid may be involved. Plasma aldosterone has not been previously examined.

Gerbils forced to rely on 6.0% NaCl as drinking solution lost weight rapidly, hemocentration, and demonstrated elevated numbers of zona fasciculata mitotic figures. Zona glomerulosa atrophy was not observed. Plasma aldosterone was diminished in the first three weeks and demonstrated an increase by the ninth week. A reversal of dehydration was noted by the ninth week.

Sodium chloride deprivation did not induce glomerulosa hypertrophy. Plasma aldosterone was uniformly elevated.

Fasciculata mitotic figures in sodium chloride stressed gerbils implicate glucocorticoid secretion as an important stress prophylactic.

MORPHOGENESIS OF LYMPHOCYTES IN REDUCED FETAL CALF SERUM MEDIUM. Patricia Goad, Bernard Parker, and Evelyn Jemison, Cytogenetics Laboratory, Department of Life Sciences, Virginia State University, Petersburg, Virginia 23803

A new medium with donor plasma fractions as a fetal calf serum substitute or supplement is being developed for lymphocytes growth. Phytohemagglutinin stimulated lymphocytes are cultured from peripheral blood fractions collected in sodium citrate vacutainers. Previous results of this experiment established twelve percent fetal calf serum with tissue culture medium 199 which produced optimum growth for bioassay. Lymphocytes transformation and chromosomal configuration were used as parameters in comparing the effectiveness of the medium. Results: twelve percent fetal calf serum (FCS) promoted optimum growth of lymphocyte cells, eight percent (FCS) with four percent autologous plasma supplement was effective for maintenance of leucocyte cultures for 48 hours only, four percent FCS with eight percent autologous plasma did not promote enough blastogenic and mitogenic response or cell maintenance as needed for bioassay. (Supported by NIH/MS Grant 806-RX-08090-09).

INFLUENCE OF PHOTOPERIOD AND NUTRITION ON BODY WEIGHT AND REPRODUCTIVE ORGAN WEIGHTS IN THE PINE VOLE. J.J. Hasbrouck*, R.L. Kirkpatrick, A.R. Tipton, and J.A. Cranford, Dept. of Fish and Wildl. Sci. and Biology, VPI&SU, Blacksburg, VA 24061

The influence of nutrition and photoperiod on reproductive performance of the pine vole (*Microtus pinetorum*) was examined in two experiments. In the first, two males and five females were placed in concrete troughs (2.3m²) for 12 weeks. Half of the groups were kept on a 14:10 photoperiod and the remainder on a declining photoperiod. Within each lighting regime, half of the groups were given apples as a dietary supplement. All groups received ad libitum amounts of rabbit chow. Mean weights for seminal vesicle, testes, uterus and paired ovaries were significantly lower ($P<0.05$) in voles on the declining photoperiod. Mean testes weight and female mean body weight were significantly increased ($P<0.05$) with an apple supplement. The second experiment was conducted in an environmental chamber. Male-female pairs with a known reproductive history were separated into two groups, one on a 9:15 and the second on a 15:9 photoperiod. Within each photoperiod, half of the pairs were given an apple supplement. All pairs were fed ad libitum quantities of horse chow. The experiment ran only 4 weeks due to technical problems. Mean seminal vesicle weight was significantly lower ($P<0.1$) in males on the 9:15 photoperiod. Males on a chow diet had a significantly higher ($P<0.05$) mean body weight and mean seminal vesicle weight.

SELECTION FOR REDUCED SEXUAL ATTRACTION IN THE IXODID TICK DERMACENTOR VARIABILIS (Say). P. J. Homsher and D. E. Sonenshine, Dept. of Biological Sciences, ODU, Norfolk, VA 23508.

The sex pheromone of the American dog tick, *Dermacentor variabilis* (Say) has been identified as 2,6-dichlorophenol. This chemical is found complexed with a neutral lipid in the foveal glands of the female and is released through the foveae dorsales when stimulated by the feeding process in the adult tick. The objective of this study was to determine if some part of the synthesis or release mechanisms could be selected against to produce females that were unattractive. Four generations of selection for the least attractive females resulted in producing only three females in the only line that remained by then. These females were difficult to mate (requiring the addition of the sex pheromone to the external dorsal surface in one) and, although all three laid eggs, two egg clutches had no viable embryos and one had 54 of 1961 eggs hatch (2.8%). However, foveal glands from these females were found to have a normal amount of 2,6-dichlorophenol (2.6ng/tick), indicative that the selection observed affected the release mechanism for the pheromone rather than the synthesis mechanism.

EFFECTS OF GALVANIZED VERSUS STAINLESS STEEL CAGING ON LIVER AND KIDNEY CONCENTRATIONS OF TRACE METALS IN WHITE MICE. Edwin J. Jones* and Richard T. DiGiulio*, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Liver and kidney trace metal concentrations were determined in ICR mice raised in stainless steel (SS) and galvanized (GAL) hanging cages. Six and 9 weanling mice were housed in pairs in SS and GAL cages, respectively, for 12 weeks. No differences were observed between groups in initial body weight, final body weight, liver weight, and paired kidney weight. Liver and kidney dry weight metal concentrations were determined by flame atomic absorption spectrophotometry. A significant difference ($P<0.03$) was observed in liver zinc (Zn) concentrations between GAL ($83.86 \pm 5.77 \mu\text{g/g}$; $\bar{X} \pm \text{S.E.}$) and SS (55.60 ± 11.03) groups. Liver copper (Cu) tended to be higher in GAL (13.98 ± 1.80) than in SS (11.06 ± 1.88). Only 1 mouse in each group had detectable liver cadmium (Cd). Kidney Zn concentrations tended ($P<0.18$) to be higher in GAL mice (86.25 ± 18.71) than in SS mice (53.40 ± 7.65). GAL kidney Cd was higher than SS kidney Cd (0.20 ± 0.05 vs. 0.06 ± 0.06 ; $P<0.09$). No difference was observed in kidney Cu between groups (GAL 10.96 ± 0.91 ; SS 9.10 ± 1.33).

It is recommended that stainless steel cages be used when trace metals may be a factor in view of the greater amounts of kidney Zn and Cd and liver Zn observed in the mice raised in GAL cages.

CAGE CULTURE OF CHANNEL CATFISH AND RAINBOW TROUT IN A VIRGINIA POND. Louis A. Helfrich* and Richard E. Kreh*, Dept. of Fisheries and Wildlife Sciences, VA Polytechnic Inst. and State Univ., Blacksburg, VA 24061

To evaluate the biological feasibility of a double fish-crop rotational system in Virginia's warmwater farm ponds, channel catfish (*Ictalurus punctatus*) and rainbow trout (*Salmo gairdneri*) were reared in cages (1m²) suspended in a pond at the Reynolds Homestead Agricultural Station, Patrick County, Virginia. Channel catfish fingerlings (127mm), stocked in June at a density of 100 fish per cage (n=6 cages) were harvested in late October. During the 124 day growing season at a mean water temperature of 25°C, yield, net production, food conversion, and survival of channel averaged 20 kg, 16 kg, 2.02, and 84 percent per cage, respectively. Production and food conversion of channel catfish reared on a diet of commercial trout feed were significantly greater ($P<0.05$) than those fed commercial catfish feed. Rainbow trout fingerlings (127mm), stocked in November at a density of 200 fish per cage (n=2 cages) were sampled in March. After a 136 day winter growing season at a mean water temperature of 6°C, yield, net production, food conversion, and survival of rainbow trout averaged 31.0 kg, 8.6 kg, 4.50 and 94 percent per cage, respectively. The results indicate that double-cropping of channel catfish and rainbow trout in cages in Virginia ponds is biologically feasible. Large-sized fingerlings (>150mm) and high stocking densities (>250 fingerlings/cage) are recommended.

CYTOGENETIC AFFECTS OF CYCLAMATES. E. W. Jemison, K. Brown*, and B. Rivers*, Dept. of Life Sciences, Va. State Univ., Petersburg, Va. 23803

PHA-stimulated human peripheral lymphocytes were used as a model system for assessing the *in vitro* effect of calcium cyclamate. Techniques of autoradiography, cytological staining, cell counting, liquid scintillation and karyotyping were used to study the cytogenetic damage and biochemical effects of calcium cyclamate when assayed at 24 hour intervals for 96 hours. The cells were exposed to 10^{-2} and 10^{-3} molar concentrations of calcium cyclamate in TC 199 medium with fetal calf serum and antibiotics.

Data obtained from this study indicated that calcium cyclamate impaired the synthesis of deoxyribonucleic acid (depicted by decreased incorporation of radioactive thymidine into acid precipitable material), reduced grain counts in autoradiographs and increased chromosome aberrations in cyclamate treated PHA-stimulated peripheral blood lymphocytes *in vitro*. Morphological changes and growth rate showed significant effects. (Supported by Minority Biomedical Support Program, NIH Grant 1 S06 RR-08090-0).

BLOOD PROTOZOANS OF JUVENILE MOURNING DOVES FROM MONTGOMERY COUNTY, VIRGINIA. Edwin J. Jones*, Ralph E. Mirarchi*, and Patrick F. Scanlon*, Dept. Fisheries and Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Blood smears from 48 juvenile mourning doves, *Zenaidura macroura*, collected in Montgomery County, Virginia during August and September 1977 were examined for blood parasites. Gametocytes of 3 species were observed: *Haemoproteus saharovi*, *Haemoproteus macallumi*, and *Leucocytozoon murchisoni*. *H. saharovi* was observed in only 1 dove. *H. macallumi* and *L. murchisoni* were observed in 10 and 4 doves, respectively. Two mixed infections were observed. One dove harbored both *H. saharovi* and *H. macallumi*, the other mixed infection was *H. macallumi* and *L. murchisoni*. All infected doves had less than 5 gametocytes per 10,000 erythrocytes except 2 doves infected with *H. macallumi* which had 69 and 90 gametocytes per 10,000 erythrocytes.

AN EVALUATION OF ENVIRONMENTAL VARIABLES IN BROWN TROUT STREAMS OF VIRGINIA. Theresa A. Keklak* and Richard J. Neves.* Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Brown trout have been stocked in Virginia streams since 1962. While the establishment of brown trout fisheries tends to enhance fishing quality, no extensive studies have been made to identify reasons for the success or failure of these introductions. The objective of this study was to determine characteristics of Virginia streams most likely to support self-sustaining brown trout populations. The physico-chemical conditions of six streams containing brown trout were studied in order to evaluate the relationship between these factors and brown trout populations. Study streams varied in fish population abundance, vegetation type, temperature, flow, gradient, width, depth, and habitat quality. Forty-one environmental attributes were measured at study sites on each stream. Those parameters significantly correlated ($P < .05$) with brown trout biomass were used to develop multiple regression models. Of the environmental variables measured, brown trout biomass on two sampling dates (June and November) was closely correlated with alkalinity, hardness, conductivity, total phosphates, percent canopy, percent gravel sediment type, and percent rubble sediment type.

EFFECTS OF XYLAZINE HYDROCHLORIDE ON THYROXINE AND TRIIODOTHYRONINE IN WHITE-TAILED DEER. Virgil E. Kopf, David F. Gibson, Anne Oelschlaeger, Patrick F. Scanlon, Roy L. Kirkpatrick and Francis C. Gwazdauskas. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Nine white-tailed deer does were subjected to two techniques for blood collection. Blood was withdrawn during manual restraint (0 time) followed by three subsequent withdrawals during manual restraint at 15, 30, and 90 mins. after the initial restraint. The second technique was manual restraint (0 time) with injection of xylazine hydrochloride (XHCI) at the rate of 2.90 ± 0.15 mg/kg B. W. Subsequent collections were made at 15, 30, and 90 mins. after the XHCI injection. The values for circulating levels of thyroxine (T_4) and triiodothyronine (T_3) were examined for effects resulting from the method of restraint (manual vs. drug) and the time after initial restraint (0, 15, 30, 90 minutes). Analysis of variance indicated that neither the restraining technique nor the time since initial restraint significantly ($P > 0.1$) affected the circulating values of the hormones. (Supported in part by Pratt Animal Nutrition Foundation).

DISTURBANCES IN TRYPTOPHAN METABOLISM IN OSBORNE-MENDEL RATS. T. D. Kimbrough, L. B. Weekley, and M. L. Jones. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284.

In a comparative study of two rat strains fed a normal diet, parameters of normal tryptophan (Trp) and serotonin (5-HT) metabolism were measured. In comparing genetically obese Osborne-Mendel rats (O-M) to Sprague-Dawley rats (S-D), the former strain was found to have decreased hepatic tryptophan 2,3 dioxygenase (TDO) activity, while hepatic tyrosine amino transferase (TAT) activity was not significantly different. In a brain Trp uptake and 5-HT synthesis rate study, the S-D telencephalon had higher Trp levels, while the converse was observed in the brain stem. The brain 5-HT synthesis rate appeared to be reduced in the S-D brain stem relative to the O-M rat, and the O-M telencephalon may account for the hyperphagia and obesity that occurs in the O-M rat.

XYLAZINE HYDROCHLORIDE FOR RESTRAINT OF WHITE-TAILED DEER. Virgil E. Kopf, David F. Gibson, Timothy J. Dietrick, Patrick F. Scanlon and Roy L. Kirkpatrick. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. and State University, Blacksburg, VA 24061.

Restraint facilitating drugs offer the opportunity for safe, and humane intensive physiological investigation under penned conditions. Drugs can alter physiological characteristics either directly or indirectly. Clinical effects of xylazine hydrochloride (XHCI) on white-tailed deer, *Odocoileus virginianus*, were investigated at dosage rates ranging from 3.3 mg/kg B.W. to 0.1 mg/kg. Deer generally were capable of standing within 2-3 hours after injection. Deer at higher dosages had protracted recovery times. At high dosage rates (3.3 mg - 2.9 mg/kg) feed intake was reduced from 5-7 days after treatment. Feed intake at lower dosage rates (0.5, 0.25, and 0.1 mg/kg) were generally depressed for a period of 1-2 days after treatment. XHCI at low dosage rates provides a means for intensive physiological investigation in penned animals with nominal and predictable impacts on clinical and physiological characteristics together with reasonable safety for deer and personnel.

A NEW BIOLOGY: USING STRESS AS A TOOL FOR HEALTH AND CRIME. Michael P. Kratz and John C. Bartone, The American Health Research Institute, Annandale, Virginia 22003.

"Stress" has an indisputable role in health and crime and can be considered as a conglomerate quantum of which any particle can affect any life process of any human be it external or internal. The "stress of life" is an accretment of all aspects of human endeavor besides evolutionary and its multi-variate facets can be demonstrated although experimentally it can be approached as a composite entity. Stress as a "tool" need not be confined by mechanisms as proposed by Selye (1956) nor limited by the monograph works of *Social & Psychological Factors in Stress* as edited by McGrath (1970). The autonomic and physiologic responses retain their specificity. Stress *Per se* is used as a biological tool *in toto* irrespective of source and composition, and is made possible by use of an instrument known as the Psychological Stress Evaluator (PSE).

New cases and current human research is presented by use of the PSE to demonstrate that PSE-detected stress has enabled the revelation, detection and isolation of (1) guilt and hostility; (2) substance abuse as alcoholism and nicotine (3) drug abuse as misuse of prescription medication; (4) academic cheating; (5) isolated and simple shop-lifting by students, and the (6) stress of tolling lies.

Stress has been found to exist as an acute or as a chronic presence in human subjects with varying levels of low to high intensity irrespective of all other factors. Stress has been found pervasive and rendered some subjects useless.

SOME ASPECTS OF DIETARY ZINC LEVELS AND AFLATOXICOSIS IN FISCHER RATS. J. M. Kinzie* and G. C. Llewellyn. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284.

Both high and low zinc diets have been linked to possible reduction in neoplasms. Aflatoxins are potent, common natural hepatocarcinogens implicated in both animal and human acute toxic neoplastic cases. This study was undertaken to determine the possible effects of dietary zinc levels on aflatoxicosis. Thirty-six weanling male Fischer rats divided into six groups received 15, 50 (control) or 1000 ppm Zn^{++} , or 15, 50 or 1000 ppm Zn^{++} with 13.9 ppm mixed aflatoxins having 2.5 ppm as AFB₁ in Bio-Mix #893 (Bio-Serv Inc.) for 92-95 days. No reductions in hepatic neoplasms were observed with the zinc levels used. Cytochrome P-450 concentrations in the livers were decreased in the aflatoxin treated rats. The combination of high zinc and aflatoxin produced the lowest level of total cytochrome P-450. Competitive binding of aflatoxin to the cytochrome preventing formation of the Co-cytochrome P-450 complex or a loss of heme synthesis are possible explanations for this effect. Both low and high levels of zinc reduced histopathological effects in the kidneys of the rats, the latter most effectively. The better results in this respect with the high zinc levels may have been the result of altered APO metabolism to a less toxic product.

INFLUENCE OF ACUTE COLD SHOCK ON ACETAZOLAMIDE-SENSITIVE ESTERASE ACTIVITY IN THE BLUEGILL SUNFISH (*LEPOMIS MACROCHIRUS*). Stephan R. Larrick, Donald S. Cherry* and John Cairns, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508 and Center for Environmental Studies - Biology Dept., Va. Polytechnic Inst., Blacksburg, Va., 24061.

The physiological response of bluegill sunfish (*Lepomis macrochirus*) to a rapid cold shock was investigated. The critical thermal minimum (CTmin) for juvenile fish acclimated at 20 degrees C was 6.7 degrees C. Acetazolamide-sensitive esterase of branchial homogenates from 20 degrees C acclimated juvenile bluegill was 1.32 mmoles p-nitrophenyl acetate cleaved/min-mg protein. The specific activity declined to a low of 0.32 mmoles/min-mg, 21 hours after the cold shock, but increased to 1.28 mmoles/min-mg after two weeks in 8 degree C water. Activity in control fish was highest in the blood, followed by the swim bladder, liver, kidney, gill, spleen and gonads of bluegill sunfish.

A plot of reaction velocity versus substrate concentration suggested that quantitative and possibly qualitative differences between the enzyme complexed from 20 to 8 degree C acclimated fish exist. Polyacrylamide gel electrophoresis (PAGE) demonstrated that no new isozymes were induced. The differences between catalysts observed in warm and cold-acclimated bluegill was probably a result of differential rates of synthesis of the two isozymes that were already present.

THE INFLUENCE OF INORGANIC IONS ON THE OXYGEN BINDING CHARACTERISTICS OF HEMOCYANIN IN THE BLUE CRAB, *CALLINECTES SAPIDUS* RATHBUN. Richard P. Mason*, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

Alliquots of blood extracted from adult male blue crabs were dialyzed for 48 hours against various buffered (0.05 M Tris Maleate) solutions that contained common ions found in seawater. Initially, the effects of total salinity were examined. The results demonstrate that increases in inorganic ion concentration cause the respiratory pigment, hemocyanin, to bind oxygen more readily. In subsequent experiments the ionic constituents were isolated to determine which inorganic ions influence the binding of oxygen by hemocyanin. The results show that Ca^{2+} , Mg^{2+} and to a lesser extent Na are responsible for the observed oxygen binding in native blood.

THE INFLUENCE OF SOIL TEXTURE AND SOIL MOISTURE ON SOUTHERN CORN ROOTWORM LARVAE. P. F. Lummus* and J. C. Smith. VPI & SU, TRACEC, Suffolk, VA 23437.

In a growth chamber study involving 4 Virginia soils and 4 moisture regimes, survival of larvae of southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber increased as percentage clay content and percentage plant available water increased. The percentage clay content of the 4 soils ranged from 5 to 10. The lower depletion limits of the 4 moisture regimes and their respective full points were 20-30, 45-55, 70-80, and 90-100 percent of plant available water. A sharp decrease in survival was noted in the 2 lower moisture regimes, suggesting a critical plant available water value between 50 and 75 percent.

GENETIC INVESTIGATION OF ENDRIN RESISTANCE IN PINE VOLES USING STARCH-GEL ELECTROPHORESIS. J.E. McBride*, R.L. Kirkpatrick, J.J. Ney, and A.R. Tipton. Dept. of Fish and Wildlife, VPI&SU, Blacksburg, Va. 24061.

Pine vole (*Microtus pinetorum*) populations in 6 southwestern Va. apple orchards were sampled to relate the degree of endrin resistance or susceptibility present to population genetic differences. About 75 voles were trapped, before and after winter endrin application, in each of 3 orchards that had been annually sprayed with endrin for the last 15 yrs. and in 3 never-treated orchards. Oral endrin LD50 determinations revealed no apparent differences between treated and untreated orchards before spraying. LD50's ranged from 2.6-6.4 mg/kg b.w. These values were comparable to LD 50's for endrin-susceptible voles found in the literature. After spraying, LD50's in 2 unsprayed orchards were 0.6 and 3.0 mg/kg; in 2 sprayed orchards, they were 6.0 and 16.8. Four polymorphic enzyme markers were electrophoretically analyzed, 2 of which (GOT and LDH) were reported to increase in activity after endrin dosage. Two other loci (IDH and MDH) were arbitrarily chosen as random representations of the genome. In the before-spraying samples, no apparent differences in mean individual heterozygosity [no. heterozygotes/(no. individuals)(no. loci)] consistently occurred between populations from sprayed or unsprayed orchards for any combination of loci surveyed: GOT and LDH, IDH and MDH, or all 4 loci together.

CHROMOSOME/CYTOPLASMIC INTERACTIONS AFFECTING SENSITIVITY TO AFLATOXIN B TOXICITY IN *DROSOPHILA MELANOGASTER* Pamela B. Melone* and Joseph P. Chinnici,

Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284

Chromosome/cytoplasm substitution shows that resistance to aflatoxin B₁ as measured by egg to adult survival rates is genetic in *Drosophila melanogaster* and that chromosome 2 contains the majority of the resistance genes, chromosome 3 has no effect, and the effect of chromosome X depends on the type of cytoplasm present. Resistance also appears to be augmented by a cytoplasmic factor. Strains with a resistant chromosome 2 are more resistant to increasing aflatoxin concentrations if the cytoplasm is also resistant. Strains with a resistant third chromosome survive at a low rate only if the cytoplasm is resistant. This pattern appears to be reversed in the resistant Y chromosome strains. If all chromosomes are sensitive, a cytoplasmic effect is not seen, but if all chromosomes are resistant the type of cytoplasm present affects survival rates so that flies with resistant cytoplasm survive at a higher rate.

AMPHIBIANS AND REPTILES OF VIRGINIA PROJECT: COMMENTS AND UPDATE. Joseph C. Mitchell, Dept. of Biology, Univ. of Richmond, Richmond, VA 23173 and Christopher A. Pague, Lafayette Zoological Park, 3500 Granby St., Norfolk, VA 23504.

Virginia has a rich amphibian and reptilian fauna consisting of 127 species, 52% amphibians and 48% reptiles. Perhaps due to this diversity a summary volume of our knowledge of these animals has not been published. Since 1979 we have been gathering natural history data on each species with the ultimate goal of publishing a book-length summary of this information. Data collected for each species include locality records, phenotypic variation, size variation, food habits, reproductive attributes, habitat, behavior, etc. Sources of information include analyses of museum collections, field studies and the literature. To date we have examined specimens in 5 university and museum collections and have amassed field data on about 5000 specimens. Specimens collected in our efforts will be deposited in the National Museum of Natural History, which is supporting our field work. Specific studies include projects on the ecology of Virginia's freshwater turtles and an intensive survey of the herpetofauna of Back Bay National Wildlife Refuge.

SOME ASPECTS OF THE POPULATION ECOLOGY OF THE FRESHWATER TURTLES *CHRYSEMYD PICTA* AND *STERNOTHERUS ODORATUS* IN VIRGINIA. Joseph C. Mitchell, Dept. of Biology, Univ. of Richmond, Richmond, VA 23173.

Populations of *Chrysemyd picta* (Painted turtle) and *Sternotherus odoratus* (Stinkpot) have been studied by mark-recapture for two years in Laurel Lake, Henrico Co., VA. The system is eutrophic and consists of the lake, a section of Hungary Creek and a beaver pond. Population size estimates are 993 for *C. picta* and 822 for *S. odoratus*. Sex ratios are 1:1.1 (male:male to females) for *C. picta* and 1:1.2 for *S. odoratus*. Preliminary analysis indicates a stable to growing population of *C. picta* and a stable to declining population of *S. odoratus*. Male *C. picta* mature at 5 years; 3 years for *S. odoratus* males. Female *C. picta* mature at age 7, bear 2 clutches of 3-5 eggs per clutch each year, and are long-lived (some females are 20+ years of age). Female *S. odoratus* mature at age 4 and bear 2-3 clutches of 2-5 eggs per clutch per year. Few live past 10 years of age. Community associates are *Chelydra serpentina* (Snapping turtle), *Pseudemys rubriventris* (Red-bellied turtle), *Kinosternon subrubrum* (Eastern Mud turtle), and *Clemmys guttata* (Spotted turtle).

EFFECTS OF NUTRITION AND PCB EXPOSURE ON SELECTED BLOOD CHARACTERISTICS OF RACCOONS AND OPOSSUMS. W.E. Montz, Jr.,* W.C. Card,* and R.L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, VPI&SU, Blacksburg, Va. 24061

Two studies were conducted to determine the effects of nutritional restriction and polychlorinated biphenyls (PCB's) on sodium pentobarbital-induced sleeping times (ST) and selected blood characteristics in raccoons (*Procyon lotor*) and opossums (*Didelphis marsupialis*). Sixteen wild-trapped raccoons were used in a 2x2 factorial experiment and were fed either ad libitum or 70% ad libitum and 0 or 50 mg Arochlor 1254/kg body weight. After 10 days on treatment, ST's were determined, the animals sacrificed, and blood and kidney fat samples taken for analysis. Ingestion of PCB's severely reduced food consumption. Mean serum concentrations of β -hydroxybutyrate were higher in restricted animals ($P=0.05$) and in those given PCB's ($P<0.10$). Serum cholesterol levels were reduced by PCB exposure. Body weight gains were significantly greater for animals not exposed to PCB's. Neither non-esterified fatty acid concentrations (NEFA), acetoacetate concentrations, or ST's, were altered by feed level of PCB exposure ($P>0.10$). Eleven juvenile opossums received either 0 or 50 mg Arochlor 1254/kg body weight for 9 days. Mean NEFA concentrations were significantly higher ($P=0.01$) in animals given PCB's. No differences were noted in either ST's, body weight changes, or cholesterol concentrations ($P>0.10$).

ISOLATION AND CHARACTERIZATION OF APOLIPOPROTEIN B STUDIES TO EVALUATE THE POSSIBILITY OF A GENETIC VARIANT. C.L. Morey*, T.L. Thompson*, and M.F. Pinkston. Dept. of Chemistry, Mary Baldwin Coll., Staunton, VA 24401.

It is hypothesized that the development of delayed-type hypersensitivity reactions following ingestion of certain foods containing highly saturated triglycerides may result from alteration in one of the plasma lipoproteins responsible for triglyceride transport in body fluids. Preliminary electrophoretic studies have indicated that apolipoprotein B (Apo B) in a sensitive person may differ from the control. Apo B, the major protein moiety of low density lipoproteins (LDL) is characterized by extreme insolubility in aqueous solutions and tendency to aggregate when the LDL fraction is delipidated with organic solvents. Isolation of Apo B from the affected subject and normal controls is effected by precipitation with heparin and $MgCl_2$, followed by extraction with ethanol/diethyl ether. The residual apolipoprotein is solubilized with 6M guanidine chloride and cupric ammonia complexes and further purified by gel permeation chromatography in preparation for electrophoresis and isoelectric focusing. Results of electrophoresis of water solubilized Apo B appear to support the hypothesis of a genetic variant.

A MICROCOSM STUDY OF THE INTERACTIONS OF CADMIUM AND SEDIMENTS IN AQUATIC SYSTEMS. C. K. Moses* and C. L. Thomas. Dept. of Biology, Ferrum College, Ferrum, Va. 24088

A microcosm study of the interactions of sediments and cadmium in four liter polypropylene containers was performed at Ferrum College. This study was designed to answer the question: how does the presence of sediments affect the perturbation of an aquatic system by a heavy metal (cadmium)? In this study, lasting ten weeks, it was found that the presences of sediments may reduce long-term toxicity of a heavy metal and that the sediments and cadmium may interact to yield higher production as measured by three point dissolved oxygen readings.

HOW DO PARTULA SPECIES PARTITION THEIR HABITAT? James Murray, Dept. of Biology, Univ. of Va., Charlottesville, Va. 22901, Michael S. Johnson, Dept. of Zoology, Univ. of Western Australia, Nedlands, Western Australia 6009, and Bryan Clarke, Genetics Research Unit, The Queen's Medical Centre, Clifton Boulevard, Nottingham NG7 2UH, England

Despite their close genetic relationships the species of land snails of the genus *Partula* on Moorea in French Polynesia often occur together. We have studied two sites with four species each. *Partula suturalis*, *P. mirabilis*, and *P. taeniata* are found at each site. *P. mooreana* and *P. tohiyana* complete the sets. For each snail we recorded its host plant, its location, and its relation to other snails. The variables were subjected to discriminant analysis.

The snails are not distributed at random. *P. suturalis* is arboreal, mostly on *Hibiscus tiliaceus*. *P. taeniata* is more generally distributed closer to the ground, on woody shrubs and the fern *Angiopteris*. *P. tohiyana* and *P. mooreana* are strongly associated with climbing pandanus *Freyinetia demissa*. *P. mirabilis* is intermediate in position.

The species are well separated by the discriminant analysis except for *P. mirabilis* and *P. mooreana*. The remarkable success in identifying *P. mooreana* from the functions developed using *P. tohiyana* demonstrates that these two species are ecological equivalents. (Aided by the Australian Research Grants Committee (D1-77/15705), the National Science Foundation (2A5-30), and the Science Research Council.

A HERPETOFAUNAL SURVEY OF BACK BAY NATIONAL WILDLIFE REFUGE: A PRELIMINARY REPORT. Christopher A. Fague, Lafayette Zoological Park, 3500 Granby St., Norfolk, VA 23504 and Joseph C. Mitchell, Dept. of Biology, Univ. of Richmond, Richmond, VA 23173.

Back Bay National Wildlife Refuge is located in the southeast corner of Virginia and is composed of barrier beaches, slightly brackish Back Bay, and small islands within in Back Bay. A survey of the amphibians and reptiles now in progress has confirmed the presence of 26 species, 8 amphibians and 18 reptiles. Several other species are thought or known to be present. However, many conspicuous members of the southeastern Virginia herpetofauna are apparently absent, including: *Sternotherus odoratus*, *Clemmys guttata*, *Sceloporus undulatus*, *Eumeces* spp., *Thamnophis sirtalis*, *Diadophis punctatus*, *Ambystoma contortrix*, *Plethodon* spp., *Eurycea* spp., *Ambystoma* spp., *Acris* spp., *Hyla chrysocelis*, *Rana palustris*, and *Rana clamitans*. In fact, approximately 50% of southeast Virginia's herpetofauna is not found on the refuge. This may be attributed in part to the long term ecological changes accompanying post-glacial coastal inundation. Data are being collected on the reproductive biology and ecology of as many species as possible, especially within the context of the effects, if any, of the habitat management for waterfowl. It is apparent that habitat management has had a large effect on turtle ecology.

DISMAL SWAMP MAMMALS - PAST. R.K. Rose, Dept. of Biological Science, Old Dominion University, Norfolk, VA 23508.

Although the history and lore of the Great Dismal Swamp is rich with accounts of abundant wildlife of many kinds, relatively few studies of birds and mammals have been conducted there. Investigations of mammals in the 1895-1898 period by the U.S. Biological Survey were followed by less intensive surveys, mainly in the thirties and fifties. The Swamp, it turns out, does have a handful of mammals not found elsewhere in Virginia, including five distinctive subspecies. Habitat changes in the Swamp may be favoring some species and hurting others.

EFFECTS OF FORMALIN PRESERVATION ON TISSUE WEIGHTS OF BIRDS. Patrick F. Scanlon, Alan G. Clark and John Whelan. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Tissues from organs of 40 Japanese quail, *Coturnix coturnix japonica*, and 11 mallards, *Anas platyrhynchos*, were weighed and preserved in 10% formaldehyde for 138 days (quail) or 27 days (mallards). The tissues were then reweighed and differences noted. Changes in the following quail tissues were observed (number of observations in parentheses): heart (39) -3.63%; liver (36) -15.22%; intestine (3) +3.92%; glandular stomach (39) +0.57%; and gizzard (39) +1.01%. Changes in the following mallard tissues were noted (number of observations in parentheses): heart (11) -24.97%; liver (10) -22.35%; kidney (11) -27.77%; spleen (11) -24.97%; glandular stomach (11) -11.67%; intestine (11) -14.87%; and gizzard (11) -8.29%. The changes resulting from formalin preservation seemed to vary with tissue studied and possibly with species and length of preservation.

ASPECTS OF MOURNING DOVE NESTING IN VIRGINIA.

Patrick F. Scanlon, Janet E. Clarke, Catherine J. Flick, and W. Hassel Taylor. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Portions of the WP1 & SU campus were searched weekly for mourning dove nests during the 1979 and 1980 breeding seasons. Sixty-three nests were found in 10 species of trees of which all but one species were conifers. Nesting commenced as early as March and nests were not initiated later than August. Twenty-seven of 47 nests located in 1979 successfully produced young. Mean (\pm S.E.) number of eggs laid was 1.88 ± 0.05 , of which 1.81 ± 0.07 were hatched and 1.67 ± 0.09 were fledged. In 1980 6 of 16 nests were successful with 1.86 ± 0.14 eggs laid, 1.80 ± 0.2 eggs hatched and 1.6 ± 0.24 young fledged. Causes of nest failure which could be assigned were weather (wind), human disturbance, and death of parents. Many of the nests were located in non-native tree species. Reuse of nests was observed in 16 of 63 instances. (Supported by P/R Project No. W-40-R-27).

LEAD CONCENTRATIONS OF MALLARD DUCK LIVERS INGESTING LEAD PELLETS AND/OR SHOT BY LEAD PELLETS. Patrick F. Scanlon, Timothy J. Dietrick, and J. Thomas Jones. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Forty mallard ducks, *Anas platyrhynchos*, were randomly assigned within the experiment. Half were dosed orally with 4 number 4 lead pellets; the other half was left untreated. After 4 days all 40 were sacrificed. Half of each of the above groups were sacrificed by decapitation, the remaining individuals were shot with No. 4 lead pellets from a 12 gauge shot gun from a range of 20 m. Livers were dissected from each individual. Livers from each shot duck were examined for penetration by lead pellets. Analyses of lead concentration of livers of all ducks were conducted by Atomic Absorption Spectrophotometry. All ducks not ingesting lead shot had lead concentrations below the limit of detection ($0.2 \mu\text{g/kg}$ dry weight) whether shot or decapitated. Seven of the shot individuals had evidence of pellets penetrating their livers. Mean (\pm S.E.) lead concentrations of livers of ducks ingesting lead shot were $187.6 (\pm 49.2) \mu\text{g/g}$ for decapitated ducks and $105.2 (\pm 17.6) \mu\text{g/g}$ for shot ducks. It was concluded that shooting with lead pellets did not increase lead concentrations of livers of the shot subjects, a finding important relevant to the value of hunter killed animals as sources for monitoring environmental contamination.

FORAGE DIGESTIBILITY FOR WHITE-TAILED DEER, *Odocoileus virginianus*, IN LOBLOLLY PINE, *Pinus taeda*, PLANTATIONS DURING THE SPRING AND FALL SEASONS. John J. Scanlon, T. L. Sharik and R. L. Kirkpatrick. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Digestible energy was estimated for 3 forage classes (leaves of deciduous woody plants, forbs, and grasses) using a Van Soest chemical analysis. The predicted digestibility of forbs and leaves of woody plants increased slightly through the spring season to a maximum level (80%) in June, and declined in early fall to a low of 69% in October. A secondary increase occurred in November (74% digestible), when available forage was limited to a few succulent, late season species. Increasing digestibility was associated with higher ratios of cell solubles to lignin for both forage classes. The digestibility of grasses increased steadily through the spring season to a maximum level (87%) in June, and declined throughout the fall season to a low of 67% in November. Grasses maintained a high proportion of cell wall contents (60%) in all months, and an increase in the ratio of cellulose and hemicellulose to lignin in the cell walls resulted in higher digestibility for grasses. A large and important component of total digestible energy available to deer is supplied by herbaceous vegetation. Management efforts could be directed toward increasing this production by removing hardwood sprouts from stands in the pre-crown closure stage (up to 12 years old).

THE PALEOECOLOGICAL SIGNIFICANCE OF BENTHIC ALGAL MATS IN ANTARCTIC LAKES. G.M. Simmons, Jr., B.C. Parker, R.A. Wharton, Jr., F.G. Love, and K.G. Seaburg. Dept. of Biology, V.P.I.&S.U., Blacksburg, VA 24061.

The dry valley lakes of southern Victoria Land, Antarctica contain algal mats dominated by blue-green algae and diatoms. Higher forms of life such as crustacea, mollusca, insects and fish are absent. The lakes are permanently covered by 3.0-5.5 m of ice which absorbs 80-99% of incident radiation. The benthic algal mats existing beneath the ice-cover structurally are similar to those existing during the Precambrian Period 600 million years ago. The ecological nature of these lakes suggests modern analogs of Precambrian ecosystems. Algal laminated structures have been observed in the lakes studied and represent one of the few cases of freshwater stromatolite formation. The benthic habitat of these lakes may resemble ancient deep-water habitats because of light extinction, low temperature, and absence of internal currents due to ice-cover. The variability of limnological properties between the lakes provides a basis for interpreting the environmental factors governing ancient stromatolite form and structure.

INDIRECT IMMUNOFLOUORESCENCE MICROSCOPY AS AN AID TO FISH

TAXONOMY. E. N. Sismour, Steven B. Ackerman and R. S. Birdsong, Dept. of Biol. Sci., ODU, Norfolk, VA 23508

Black drum (*Pogonias chromis*) and grey trout (*Cynoscion regalis*) are members of Sciaenidae and spawn concurrently in the Chesapeake Bay. Studies of the early life history of these and other fishes are often hampered by an inability to identify eggs and larvae. Investigations were conducted to determine the feasibility of employing immunologic techniques for identification purposes. Antisera to black drum and grey trout eggs were generated in rats by immunization with homogenates of unfertilized eggs. Immunological specificity was observed when anti-black drum antiserum was tested against fertilized black drum eggs by indirect immunofluorescence. However, cross-reactivities were noted when these antisera were tested against unfertilized eggs of both species. Results indicated that specific antibodies can be developed which may be used in conjunction with meristic features in taxonomic evaluation of eggs and larvae.

SEX PHEROMONE ACTIVITY IN IXODID TICKS: A REVIEW. D. E. Sonenshine and P. J. Homsher, Dept. of Biological Sciences, Old Dominion University, Norfolk, VA. 23508.

Pheromones constitute an important component of animal communication systems. In the hard ticks (Ixodidae), a general sex pheromone, 2,6-dichlorophenol, attracts sexually active (SA) males to feeding females for mating. This compound excites feeding males, stimulating them to detach. It also assists the SA males in locating the female and identifying it as a suitable sex partner. This pheromone, found only in mature adult females, is released only during feeding. The pheromone is stored, apparently, in lipid secretory droplets in a pair of lobular glands below the dorsal cuticle. Secretion of pheromone occurs when the secretory droplets pass through the elaborate system of ducts and pores of the fovea dorsalis and on to the external surface. Individual pores can be opened or closed, providing a mechanism for regulating secretion. The possible existence of other pheromones or repellents which may be used to minimize interspecific matings is being explored. (Aided by NIH grant AI10,986).

A SURVEY OF THE HELMINTH PARASITES OF RATS, *RATTUS NORVEGICUS*, FROM MAYMONT PARK, RICHMOND, VIRGINIA. G.A. Spatafora* and T.R. Platt. Dept. of Biology, Univ. of Richmond, Richmond, VA. 23173.

Twenty-one male rats were examined for the presence of helminth parasites. Fifteen rats (11 juveniles, 4 adults) were collected in the fall of 1980 and six animals (2 juveniles, 4 adults) were collected in the spring of 1981. Two species of nematodes, *Heterakis spumosa* and *Nippostrongylus brasiliensis*, and the cestode, *Hymenolepis nana*, were found. Each species demonstrated a high degree of site specificity within the intestine.

Eighty percent of rats collected in the fall were infected with *N. brasiliensis* and *H. spumosa*, respectively. Mean densities were 102.3 and 35.9, for these species, respectively. Sixty seven percent of the rats harbored both species concurrently. *Heterakis spumosa* and *Hymenolepis nana* were found in 83 and 33%, respectively, of rats collected in the spring. Mean density was 60 for *H. spumosa* and 36 for *H. nana*.

Trichinella spiralis and *Capillaria hepatica* were not found.

SMALL MAMMALS OF THE DISMAL SWAMP. J. F. Stankovich*, and R. K. Rose. Dept. of Biol. Sci., ODU, Norfolk, VA 23508

Small mammals were studied on two grids in clearings of the Dismal Swamp of Virginia. Using Pith live traps, eight species were captured in vegetation dominated by cane (*Arundinaria gigantea*), softstem rush (*Juncus effusus*), sedges and grasses. These results were further compared to recent studies of Dismal Swamp small mammals in similar type vegetation and forested habitats.

THYROID FUNCTION IN JAPANESE QUAIL CHICKS (*Coturnix coturnix japonica*) F. W. Stanton and F. M. A. McNabb, Department of Biology, VPI & SU, Blacksburg, VA. 24061

The objective of this study was to describe thyroid activity during the post-hatching period when quail chicks are developing thermoregulatory control. It was postulated that thyroid activity would be positively correlated with the intensity of metabolic heat production. Previous studies have shown that an increase in insulation (plumage), and decreases in cutaneous evaporative water losses and surface: volume ratios contribute to the increased resistance to heat loss during the first 3 weeks after hatching. Thus, metabolic demands for endogenous heat production are decreased during this time.

Thyroid activity, as indicated by both thyroidal ^{125}I uptake and plasma thyroxine concentrations, is high in the early post-hatching period when metabolic demands are high (hatching activity and initial thermoregulatory responses). In 3-6 day chicks, while yolk reabsorption is occurring and chicks are not gaining metabolically active tissue, thyroid activity is low. In 8-21 day chicks thyroid activity increases but at a slower rate than the increases in thyroid and body weights (which parallel each other). Thus during this period thyroid activity, on a weight-specific basis decreases slightly, concurrent with the lessened metabolic demands. Thyroid activity in 21 day chicks is slightly higher than that of adults.

THYROTROPIN STIMULATION IN EMBRYONIC JAPANESE QUAIL (*Coturnix coturnix japonica*). F. W. Stanton, F. M. A. McNabb, and R. T. Weirich.* Dept. of Biology, VPI & SU, Blacksburg, VA 24061.

The development of embryonic thyroid function in quail suggests two phases of stimulation by thyroid stimulating hormone (TSH) from the pituitary. From days 10-15 of incubation thyroid activity increases at a rate moderately greater than the rate of thyroidal growth. During the perinatal period there is a burst of very high thyroid activity and marked changes in the hormone ratios suggestive of increased hormone turnover, utilization or degradation.

This study investigated thyroidal responsiveness to TSH during the latter half of incubation. Preliminary studies indicated that embryonic thyroids were unresponsive to single doses of exogenous TSH (bovine, ovine or avian), as indicated by traditional bioassay techniques using ^{125}I or ^{32}P uptake to indicate thyroid activity. Endogenous TSH release, stimulated by negative feedback using thiourea, produced a measurable thyroid response as indicated by thyroidal hypertrophy or thyroidal ^{32}P uptake. The decrease in plasma thyroxine concentrations that elicits this negative feedback response is marginally detectable by the RIA method used. The increases in thyroid functional capacity, as indicated by ^{32}P uptake, appear to be in simple proportion to the degree of thyroidal hypertrophy. In contrast to other species, thyroidal ^{125}I uptakes do not increase with TSH stimulation. Maturation of the feedback system has occurred by days 10-11 of the 16.5 day incubation period.

BREEDING BIRDS OF HARDWOOD LEAVE STRIPS IN VIRGINIA'S CENTRAL PIEDMONT. J. F. Tassone* and T. L. Sharik. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Twelve hardwood leave strips in various aged loblolly pine stands in Virginia's central Piedmont were studied to determine distributions of breeding birds in relation to features of vegetation and landscape, and to evaluate the potential of leave strips as breeding habitat. Occurrence of 38 probable breeding species was related to 14 measured variables through the use of ordination on principle components and graphical techniques. A variety of variables relate to different species distributions. Buffer strip width, stream size, foliage density in the understory, and overstory stem densities in various diameter classes are suggested as key factors influencing distributions of several forest breeding species. Properly managed leave strips would be of great potential value as breeding bird habitat in intensively managed pine plantations.

BREEDING BIRDS OF TWO ATLANTIC WHITE CEDAR STANDS (CHAMAECYPARIS THYOIDES) IN THE GREAT DISMAL SWAMP. K. A. Terwilliger*, Wildlife Biologist, Dismal Swamp N.W.R., Suffolk, Va. 23434

Breeding birds were censused in two Atlantic White Cedar stands in order to describe the avifauna of this vanishing community and provide a data base for future management and comparison. The two stands, representing different ages and vegetation structures, supported different densities and diversities of bird life. The older, structurally more complex stand was richer in species but poorer in density than the younger stand. Spatial distribution of the birds in the stands was analyzed in terms of vertical height diversity and niche breadths. Vertical distribution differed between stands and cluster analysis grouped avifauna into distinct height associations. Cedar stand census results were compared to those of the predominant swamp community (maple/gum) and were found to be less diverse but more dense. Avifauna of the older cedar stand was found to be more similar (66.8%) to the maple/gum site than to the younger cedar site (52.8%). Insectivores, as in most coniferous habitats, dominated the cedar avifauna, as Parulidae outnumbered all other families combined.

TEMPORAL RELATIONSHIPS BETWEEN CALCIUM, CHITIN, AND PROTEIN IN THE CUTICLE OF POSTMOLT BLUE CRAB, *CALLINECTES SAPIDUS*. David A. Vigh and James E. Dendinger. Dept. of Biology, James Madison Univ., Harrisonburg, Va. 22807

The temporal relationships of the deposition of calcium, magnesium, chitin and protein were studied in the postmolt cuticle of the blue crab, *Callinectes sapidus*.

Detectable calcification began some time between 10 and 24 hrs postmolt and continued through at least 68 hrs postmolt, at which time the calcium was 6.4 mg/cm² cuticle, or 22.2% of the sample dry weight (SDW).

Magnesium deposition was first detected approximately 90 min postmolt, reached a maximum value of 0.52 mg/cm² cuticle, (4.2% SDW) and declined to 0.34 mg/cm² cuticle (1.1 SDW).

The relative amount and rate of chitin deposition was less than that of calcium. By 69 hrs postmolt, chitin was 3.31 mg/cm² (11% SDW).

The average concentrations of sclerotin and arthropodin were 0.79 mg/cm² and 0.92 mg/cm² cuticle, respectively, and no new deposits of these proteins were detected up to 69 hrs postmolt. In contrast, HCl-soluble protein increased to 3.2 mg/cm² (10.7 SDW) during the same time interval.

Nuclear Thyroid Hormone Receptors in Quail Hepatocytes Richard T. Weirich and F. M. Anne McNabb, Dept. of Biology, VPI & SU, Blacksburg, VA 24061

Avian nuclear thyroid hormone receptors were characterized using liver, a thyroid hormone-responsive tissue, from adult male Japanese quail. Since T₃ binding to nuclear receptors appears to initiate thyroid hormone action in mammals, T₃ receptors were the primary focus of this study.

Fresh liver nuclei were suspended in an augmented Tris-HCl buffer. Receptor binding was maximal at 20° from 60-120 min; pH optimum was 7.4. Receptor specificity for T₃ was established; nonspecific binding was <15% of total.

Binding reversibility was shown by displacing radioactive hormone with unlabelled T₃. Scatchard analysis indicated equilibrium dissociation constants of 1.31 x 10⁻⁸ M (range 0.55 - 2.80 x 10⁻⁸ M; N = 6 experiments) for a single class of receptors. Binding capacities were within the range for mammalian liver tissue. Competition studies indicated highest affinity of the receptor was for L-T₃, closely followed by D-T₃, then by L-T₄, D-T₄, and L-T₂. MIT and DIT did not compete with L-T₃ for receptor binding.

The nuclear T₃ receptors in quail liver have characteristics similar to those in mammals. However, the data suggests L-T₃ has greater receptor affinity in birds than in mammals. (Aided by a Biomedical Research Support Grant, VPI & SU)

FREQUENCY OF *Oaethostoma myanaktii*, IN KIDNEYS OF RIVER OTTERS IN VIRGINIA. John Mhelen, Karen L. Anderson and Patrick F. Scanlon. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

During the winters of 1979-80 and 1980-81 river otter, *Lutra canadensis*, carcasses were collected in Virginia and 358 kidney pairs (201 in 1979-80; 157 in 1980-81) were examined for infestation with *Oaethostoma myanaktii* (Anderson 1964). *G. myanaktii* was recovered from the tubules of the kidneys, the anterior ends in some instances being in the connective tissue. The maximum number recovered from a kidney was 7; 13 being the greatest number from a pair of kidneys. Of all otters examined, 53.35% were infested (56.72% in 1979-80; 49.04% in 1980-81). In the 1979-80 season a higher percentage of males was infested, while in 1980-81 an equal number of both sexes were infested. The percentage of kidneys infested in each class was: (1979-80) 0-1 yrs., 54.1%; 1-2 yrs., 61.7%; 2-3 yrs., 70.6%; 3-4 yrs. 57.1%; 4-5 yrs., 42.9%; (1980-81) 0-1 yrs., 48.9%; 1-2 yrs., 61.1%; 2-3 yrs., 38.9%; 3-4 yrs., 53.3%; 4-5 yrs., 50.0%; 5-6 yrs., 50.0%.

THE EFFECTS OF CRYOPRESERVATION ON THE HUMAN LYMPHOCYTE'S CAPACITY TO PRODUCE LEUKOCYTE INHIBITORY FACTOR (LIF)

G. K. Whitaker* and M. P. Pinkston, Dept. of Biochemistry, Mary Baldwin College, Staunton, VA 24401.

LIF inhibits the migration of normal polymorphonuclear leukocytes (PMNs) incubated in its presence. This factor is characteristically produced in cases of delayed-type hypersensitivity, both *in vivo* and *in vitro*, by sensitized lymphocytes in the presence of the specific sensitizing agent. Its production can also be stimulated non-specifically by very low concentrations of mitogens.

Since fresh blood samples of sensitive persons are difficult to procure on a continuing basis, a means of preserving lymphocyte samples to permit testing of different possible sensitizing agents over a period of time is needed. Cryopreservation of lymphocytes in Liquid N₂ has been shown to allow retention of most functions. We have sought to determine if, after cryopreservation in a 2-stage crash-freezing process, lymphocytes of normal and sensitive persons can maintain their viability and capacity to produce LIF.

Production of LIF after non-specific stimulation with phytohemagglutinin has been determined by the Leukocyte Migration Inhibition Assay, using the agarose microtrophet method. When incubated in supernatant from unstimulated cells, normal PMNs migrate beyond the limits of the agarose droplet; when incubated in supernatant containing LIF, they remain within its bounds.

Results to date are promising; we are not yet fully successful in maintaining viability after cryopreservation.

THE TRINOMEN AND THE ENDANGERED SPECIES ACT. Raymond R. White, Dept. of Biology, Old Dominion University, Norfolk, Va. 23508

The subspecies level of taxonomy remains in general use. It is sanctioned but undefined by the International Code of Zoological Nomenclature. Unfortunately the definitions in use vary greatly. Some taxonomists would assign subspecific rank to two populations if 75% of either population can be told from 90% of the other on the basis of at least one character. Some would do so only if the populations are partly isolated in terms of gene flow, as well. Others would require that several characters be different. The Endangered Species Act allows protection of subspecies, but does not define the term.

What I propose is that only populations that differ in five or more characters and are partially isolated with respect to gene flow should be recognized as subspecies. Thus, only a well differentiated population that has its own unique evolutionary potential can be recognized at the subspecific level and protected by the Endangered Species Act.

BLASTOGENIC RESPONSES OF POOLED AND UNPOOLED LYMPHOCYTES. Trenia Winbush, and Fvelyn Jemison, *Cytogenetics Laboratory, Department of Life Sciences, Virginia State University, Petersburg, Virginia 23803

Blastogenic responses of pooled and unpooled leucocyte cells from peripheral blood fractions are assayed after exposure to phytohemagglutinin and varied concentrations of fetal calf serum. Three different culture media are used for each experiment: (1) TC 199 medium + 8% FCS (2) TC 199 medium + 4% FCS + 4% donor plasma and (3) TC 199 medium + 2% FCS + 6% donor plasma. Each vial contains 9.2 ml of TC 199 medium, .5 ml of PHA, and .2 ml of antibiotics. Hemacytometer counts are taken at 24 hour intervals for three (3) consecutive days. Preliminary results of this experiment, when using pooled leucocytes supplemented with two percent fetal calf serum (FCS) and six percent donor plasma indicated optimum growth of leucocyte cells; eight percent FCS without donor plasma and four percent donor plasma effectively maintained leucocyte cultures for 72 hours. (Supported by NIP/MRS grant 806-RR-08090-09)

KEPONE LEVELS OF SELECTED TERRESTRIAL ANIMAL SPECIES FROM THE JAMESTOWN ISLAND AREA. Cynthia L. Willard-Mack* and C. Richard Terman, Biology Dept., College of William and Mary, Williamsburg, Va. 23185.

Comparisons were made of the Kepone levels in the livers of a minimum of 5 individuals of several species of vertebrates from Jamestown Island (J.I.) and the Ecological Study Area (control) of the College of William and Mary. The species sampled and the Kepone levels (ppm) of the J.I. animals were: Colubridae and Viperidae snakes (4.09±1.650), Blarina (.96±.380), Didelphis (1.21±.574), Procyon (.42±.170), *Peromyscus leucopus* (.31±.079), *Sciurus* (.23±.075), *Terrapene* (.02±.007), *Sylvilagus* (.01±.004), and *Odocoileus* (non-detectable [n.d.]). With the exception of the last three, the mean Kepone levels were significantly higher than in the control animals.

The whole bodies of several individuals of five invertebrate groups were pooled and the samples analyzed yielding the following means: *Lumbricus* (n.d.), *Acrididae* (n.d.), *Gryllidae* (n.d.), *Silpha* (.27), and *Microthema* (.40).

The mean Kepone load of the J.I. vertebrates increased in the following order: granivores (.27±.054), omnivores (.54±.201), and carnivores (2.78±1.050). Variability also increased with the mean Kepone content suggesting a non-uniform exposure at least at the higher levels of the food chain. Similar trends were observed in the control animals to a lesser degree. These data confirm that Kepone contamination of the terrestrial ecosystem is extensive.

SOCIAL BEHAVIOR, GROWTH CHARACTERISTICS, AND REPRODUCTIVE ORGAN WEIGHTS OF WHITE-FOOTED MOUSE (*PEROMYSCUS LEUCOPUS NOVEBORACENSIS*) POPULATIONS IN THE LABORATORY. Charles C. Wolfe and C. Richard Terman, Dept. of Biology, Coll of William and Mary, Williamsburg VA 23185.

Four populations of white-footed mice were founded by placing four bisexual pairs in each of four 20 sq ft circular enclosures containing eight nest boxes. Food and water were supplied in surplus and the populations were observed 1/2 hour 2-3 times a week until growth ceased (no young surviving during a period of 150 days). All animals were checked on a bi-weekly basis for reproductive condition. The populations were sacrificed after growth had ceased and selected organs of individual animals were weighed. Bisexual pairs were placed in galvanized steel cans with a diameter of 48.26 cm to act as controls. Two nest boxes were provided and all other environmental conditions were similar to the above except the young were removed at weaning.

Each population was characterized by a high level of aggressiveness resulting in the death of 3 of the 4 founding males. Growth occurred in 3 of the 4 populations after this period. The populations attained variable numerical levels at asymptote with the control of growth being achieved either by cessation of reproduction or failure of young to survive.

Aggressiveness appears to be inversely related to litter survival with high survival of young occurring when the level of aggression is low. Analysis of the reproductive organs and adrenal gland weights revealed no significant differences between population and control animals.

Botany

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

SUCCESS OF PINES IN THE VARC EXPERIMENTAL PINUS TAEDA FOREST. Jennie Alvernaz*, and Barry Ensley*, Dept. of Biology, Christopher Newport College, Newport News, Va. 23606

Growth of a 10-year old loblolly pine (*Pinus taeda* L.) stand was observed in 24 (6- x 24- m) quadrats on a Bladen loam in the Coastal Plain of Virginia. The study was intended as a comparison to a similar study conducted in 1979 on a nearby tract. Variables between the two studies included soil type and topographical differences. It was established that the trees in the 1979 study had significantly lower densities and proportionately fewer trees 16 feet and greater in height than those in the current study. These differences were probably due to water levels and topography changes caused in part by logging practices used when clearing the area for replanting.

RELATIONSHIP OF VEGETATION TO HYDROLOGY AND SOILS IN THE GREAT DISMAL SWAMP, VIRGINIA AND NORTH CAROLINA. Virginia Carter*, P. T. Cammon*, U.S.G.S., Reston, VA 22092, and M. K. Garrett*, U.S.F.W.S., Suffolk, VA 23434

The distribution of vegetation within the Great Dismal Swamp and on the upland-to-wetland transition zone in its western boundary is related to soil type, ground-water level, and duration of surface inundation. Changes in vegetation, water table, surface flooding, soil type, soil moisture, and soil and ground-water oxygen content are being measured in the transition zone. A preliminary quantitative analysis of three vegetation layers in the transition zone using a line-intercept method suggests that species distribution is a function of plant tolerances to the complex interaction of all the components being measured.

Preliminary data from observation wells and estimates of surface flooding in five vegetation communities on organic soils within the swamp, suggest a relationship between hydrology and community composition. Although water levels for various sites are similar during droughts, maple-gun-cypress and loblolly pine types have higher water tables than the evergreen shrub, Atlantic white cedar; and mixed hardwood sites during the growing season.

PHYTOPLANKTON IN TEMPORARY SURFACE WATERS IN A DISMAL SWAMP CYPRESS STAND. J. A. Atchue, III*, H. G. Marshall, and F. P. Day, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

During the winter and early spring standing water can be found in areas of the Great Dismal Swamp and is often populated by phytoplankton. The phytoplankton populations in a Cypress community were sampled on a twice monthly schedule from mid-January 1980 until the water disappeared in late April. A succession pattern was noted through the collection period among the 14 genera and 30 species identified, with total cell numbers ranging from 4200 cells/ml (14 Jan. 1980) to 17000 cells/ml (10 Mar. 1980). The dominant forms included the pennate diatoms, *Finnularia* spp. and *Eunotia* spp. and a cyanophyte, *Oscillatoria submembranacea*. Both *Finnularia abaxiense* and *O. submembranacea* were found throughout the sampling period. *Eunotia curvata* and *E. eudetia* were also common in most of the samples. Other less common diatoms included *Tabellaria fenestrata*, *Cymbella* sp. and *Synedra* sp. The Chlorophyta were represented by *Microspora pachyderma*, *M. tumidula* and *Oedogonium* sp. Two chrysophycean species of *Mallomonas* became important after 10 March 1980. These and other apparent successional patterns were discussed with the aid of cluster analysis.

PATTERNS OF SECONDARY SUCCESSION IN MONTANE HABITATS.

Dean Cocking, Department of Biology, James Madison Univ., Harrisonburg, VA. 22807

Shenandoah National Park was established in 1934 with the simultaneous abandonment of a mosaic of vegetation at various different stages of successional development. The heterogeneity of the montane environment and the existence of a relatively detailed vegetation map which was prepared by L. Y. Berg and R. B. Moore in the late 1930's, has made this segment of the Blue Ridge Mountains amenable to the study of the process of succession. Several James Madison University graduate students in biology including E. Baxter, D. Stoltzfus, M. Lipford and R. Overmohle have been involved in a comprehensive study of plant community composition in "meadowlands", 40-yr old fields, and "late successional" and "mature all-age" forest stands which are currently located at different elevation and slope combinations within the park boundaries.

A quantitative data base is being developed which details the community development through *Rubinia pseudo-acacia* and *Fraxinus americana* successional forests toward mature oak-hickory forests on the southeast facing slopes and forests with northern hardwood and hemlock components on the cooler northwest slopes at higher elevations. Changes in species composition and successional rates which are related to complex environmental gradients are being documented.

AN EVALUATION OF DISJUNCTNESS IN THE DISTRIBUTION OF RIVER BIRCH (*BETULA NIGRA* L.). B. F. Coyle*, T. L. Sharik, and P. P. Forst. Department of Forestry, VPI & SU, Blacksburg, VA 24061

As part of a study of morphological variation in the species *Betula nigra* L., river birch, an attempt was made to verify the existence of outlying, disjunct areas of occurrence which appear on various range maps. A review of these range maps indicated 18 separate marginal areas which are disjunct from the continuous range of the species. Of these disjunct areas, only four were verified as natural populations of river birch. The occurrence of the species in the remaining areas was apparently reported on the basis of horticultural plantings, misidentification, or small populations which have since perished. It is suggested that intensive investigations of other widespread tree species in North America are needed to verify the occurrence of presumed disjunct populations.

ISOLATION AND PARTIAL CHARACTERIZATION OF A LECTIN FROM THE SEEDS OF *CERCIS CANADENSIS* (EASTERN REDBUD). Muriel Dahlgard, Seniz Bolat*, and Karl Moldenhauer*, Dept. of Chemistry, Randolph-Macon Woman's College, Lynchburg, VA, 24503.

Seeds of *Cercis canadensis* were homogenized in phosphate buffered saline (pH 7.2) and the protein material was precipitated from the filtered extract by saturation with ammonium sulfate, followed by dialysis. Separation of the crude protein mixture by gel chromatography on a 40 x 0.9 cm. column of Sephacryl S-200 Superfine (Pharmacia), monitored at 280 nm in the U.V. region, resulted in the isolation of a lectin which showed nonspecific hemagglutinating activity against types A, B and O red blood cells.

To determine the sugar specificity of this lectin, hemagglutination was studied in the presence of D-glucose, D-galactose, D-mannose, D-glucosamine, D-galactosamine, D-mannosamine, N-acetyl-D-glucosamine, N-acetyl-D-mannosamine, N-acetyl-D-galactosamine, L-fucose and sialic acid. Only N-acetyl-D-glucosamine was found to be effective in inhibiting hemagglutination by this lectin, indicating that the lectin from *Cercis canadensis* appears to be similar to the lectin found in wheat germ.

STUDIES OF ECOSYSTEM STRUCTURE AND FUNCTION IN THE GREAT DISMAL SWAMP. Frank P. Day, Jr., and Gerald F. Levy. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Research at the plant community and ecosystem level of organization has been conducted in the Dismal Swamp in six primary categories. (1) Vegetational dynamics - The autecology of particular species (eg. *Chamaecyparis thuyoides*) and successional patterns are being examined. (2) Ecology of red heart disease - Conditions affecting the dynamics of *Pomes pini* infection are being studied. (3) Community structure - Most of the ecosystem research is being conducted in four distinct communities which differ in species composition and extent of flooding. A major goal has been to determine the affects of hydroperiod on system structure and function, eg. the flooded sites have greater basal area and biomass. (4) Primary productivity - The flooded sites also exhibit higher leaf production rates and stem diameter growth. (5) Decomposition - A major effort is in progress to fully evaluate decay processes in a swamp environment. Generally, decay is faster on the flooded sites. (6) Nutrient dynamics - Another major goal is to characterize nutrient recycling in a seasonally inundated swamp ecosystem.

EFFECTS OF LIGHT ON THE POLYPHENOLOXIDASES OF THE TETRASPORE ASCOMYCETE *PODOSPORA ANSERINA* NIESSL. Melanie A. Harper*, sponsored by James E. Perham. Randolph-Macon Woman's Col., Lynchburg, VA 24503

In vivo studies of sexuality in *Podospora anserina* Niessl have shown that light stimulates the production of perithecia. The phenoloxidases of *Podospora* have been implicated in the development of sexual structures. Tyrosinase and laccase activity levels were compared from cultures grown in the light and cultures grown in the dark. In spectrophotometric tests involving dopachrome accumulation, cultures grown in the dark were found to have a higher tyrosinase activity than cultures grown in the light. With the exception of 48-hour cultures, the activity of laccase was found to be greater in cultures grown in the light. This study shows a direct relationship between both fruiting body formation and light and polyphenoloxidase activities and light.

EFFECTS OF EXCESSIVE COPPER LEVELS ON *Skeletonema costatum* (Greville) Cleve. Susanne S. Jackman* and B. G. Marshall. Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Copper levels and dominant phytoplankton composition were examined from six sites in Kings Creek on Virginia's eastern shore from March to August 1980. Copper levels were determined by an APDC-MIBK extraction procedure and ranged from 0.003 mg/l to 0.020 mg/l. Diatoms were dominant with *Skeletonema costatum* as the major species in late summer.

Subsequent laboratory studies involved 96 hour experiments using *S. costatum* (clone Skel) grown in enriched natural sea water. The water was collected from Kings Creek and enriched according to Guillard's (1975) F/2 media levels. Cupric sulfate was added to the experimental culture media from stock solutions yielding final copper concentrations of 11.7 µM, 13.7 µM, 15.7 µM, 17.7 µM and 31.5 µM. After 96 hours copper exposed *S. costatum* cells were harvested by filtration, digested and analyzed for cellular copper content. The copper content of the control cells was below detection limits, while cells exposed to excessive copper levels ranged from 576 µgCu·g⁻¹ dry weight to 8929 µgCu·g⁻¹ dry weight. Culture media in which cells were grown and in which no cells were grown were analyzed for ionic and chelated copper levels using Chelex-100 in ion-exchange columns.

GEOGRAPHIC ANALYSIS OF THE FOREST VEGETATION OF VIRGINIA. W.C. Johnson*, T.L. Sharik, and P.W. Reilly, Dept. of Biol. and Forestry, Va. Polytech. Inst., Blacksburg, VA 24061.

The relationships between tree distribution patterns and environmental variables were examined using factor analysis. Distribution patterns of 44 tree species were determined from 4,400 sample plots of the USDA-Forest Service. Environmental parameters included temperature, precipitation, elevation and major soil groups. Five factors accounted for 53.4% of the total variance. Variables with the strongest correlations to factor 1 included *Quercus prinus* (+0.85), *Liquidambar styraciflua* (-0.85), elevation (+0.89) and mean annual temperature (-0.96). This factor represents the strong elevation and temperature gradient across the state and the species primarily restricted to either the Appalachian Mountains or the Coastal Plain. The second factor included species with maximum abundance in the Piedmont [e.g., *Juniperus virginiana* (+0.65), *Pinus virginiana* (+0.67)]. The three remaining factors were related to topo-edaphic conditions in the Appalachian Mountains (factor 3, *Pinus rigida*), old-field species in the northern Piedmont (factor 4, *Juglans nigra*) and species with maxima at intermediate montane elevations (factor 5, *Pinus strobus*). The results emphasize the primary importance of elevation (temperature) in affecting the macrodistribution of Virginia trees, with secondary patterns related to soils, local topography and land use.

FALL PHYTOPLANKTON DISTRIBUTION IN NORTHEASTERN WATERS OF THE CONTINENTAL SHELF. L. A. Kalenak* and H. G. Marshall. Depts. of Biological Sciences and Oceanography, Old Dominion University, Norfolk, Va. 23508

Surface samples were collected from 39 stations off the eastern coast of the United States in September 1980. Samples were analyzed using a modified Utermohl method. A total of 162 species were identified consisting of diatoms (84 species), dinoflagellates (53 species), cocolithophores (11 species), and representatives from six other classes.

Ubiquitous species were *Skeletonema costatum*, *Leptocylindrus danielsi*, and *Rhizosolenia pungens*. Dominant diatoms included *Rhizosolenia* spp., *Chaetoceros* spp., *Eucampia zoodiacus*, and *Asterionella glacialis*. Characteristic of the near shore were dinoflagellates and silicoflagellates. These included *Prorocentrum micans*, *Scorpiella trichothoidea*, *Distaplia speculum*, and *Ehria tripartita*. Far shore waters had a greater cocolithophore composition, with *Emiliania huxleyi*, *Gyrodactylus pulchra*, and *Rhabdosphaera clavigera* common.

In addition, an unidentified ultraplankton component was common in the samples. Average cell numbers per liter decreased from 1,400,000 cells/l at near shore stations to 157,000 cells/l at far shore stations. However, there was a distinct population increase noted along the margin of the continental shelf.

This study was supported in part by the NOAA Northeast Monitoring Program.

A QUANTITATIVE STUDY OF HARDWOOD STANDS IN BUCKS COUNTY, PA. John M. Kasmer* and Paul R. Kasmer, Jr.*. Dept. of Biology, Coll. of William and Mary, Williamsburg VA 23185.

A quantitative study was made of forty relatively old, undisturbed hardwood stands in Bucks Co., PA north of Philadelphia in the Piedmont lowland. Sampling was by the Bitterlich method and the stands were arranged in a Bray-Curtis ordination. Dominant species in most stands were one of *Fagus grandifolia*, *Liriodendron tulipifera*, *Quercus alba*, *Acer saccharum*, *A. rubrum* and *Q. velutina*. *Q. rubra* was widespread but was never the leading dominant. The x-y and y-z axes of the ordination clearly separated ten of the twelve important species. *Q. alba* and *A. rubrum* was found together, as were *L. tulipifera* and *Q. floridana*. In contrast to previous work, *Tsuga canadensis* occurred with *A. saccharum* and in good, less acid soil while *F. grandifolia* was segregated from *A. saccharum* and occurred in poorer, more acid soils. In general, the results indicate that Bucks Co. is part of Braun's former oak-chestnut region but with greater representation of mesic species, and is similar to stands previously studied in DE and S.E. PA. The importance of *A. saccharum*, *A. rubrum*, *F. grandifolia* and *Fraxinus americana* is consistent with proposed future composition of Piedmont forests in N.J.

DIRECT ENUMERATION OF HIGHER FUNGI IN SEAFOAM. Paul W. Kirk, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

A flotation method was devised for direct enumeration of fungi in seafoam, beach sand and wreck, the water column and surface layer (wire screen samples) of inshore waters. Samples were taken in Virginia Beach at high and low tides, during calms and on-shore winds, throughout the fall of 1980.

Samples were decanted to remove sand, formalinized, and settled for 1 week before supernatant was siphoned off. Sediments were washed centrifugally to remove salt, and their concentration adjusted to about 100mg dry weight per ml of 5% formalin. Samples (0.5ml) were centrifuged in several 2.5ml washes of 70% (w/v) (NaPO₃)₂ to free spores from clay particles. Suspensions were diluted in 25ml persep settling chambers, and after 12 hours the settled spores and hyphae were counted with an inverted microscope using random fields as needed.

The method was far more sensitive and precise than others in use, and broadly applicable to marine mycology. Virginia was established to be the northern limit of *Varicosporina remulosa*. Over 32 fungal taxa were present in amounts as high as 2 million propagules/g of sand- and salt-free foam. Many spores of *Coriolospora* spp. in wreck were shown not to originate there, but in sublittoral sands from which they are transported in seafoam.

A MYCOSTATIC PRINCIPLE IN SEAWATER. Paul W. Kirk, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

A mycostatic principle resembling that in soils was identified in waters of various salinities from Virginia Beach and the Elizabeth River estuary. Spores of six terrestrial species in *Aspergillus*, *Penicillium*, *Fusarium* and *Trichoderma*, and those of the presumed facultative marine fungus, *Dendryphiella salina*, showed little or no germination in raw seawater from any source, whereas spores of three obligate marine fungi were uninhibited and another only slightly.

The species inhibited by raw seawater were not by autoclaved seawater of the same salinity. Mycostasis was also annulled by heating raw seawater to 50°C for 1 hr., by evaporation and reconstitution with distilled water, charcoal filtration, extraction with organic solvents, and the addition of glucose or ammonium phosphate.

Seawater stored for long periods in polyethylene carboys was more inhibitory than fresh seawater in glass containers, although both types of raw samples supported lower germination percentages than the autoclaved samples. The possibility of interference by ethylene derived from plastic containers was noted. The salinity of media on which spores were produced also affected results.

PHYTOPLANKTON ASSEMBLAGES WITHIN THE CHESAPEAKE BAY PLUME AND ADJACENT WATERS OF THE CONTINENTAL SHELF. Harold G. Marshall. Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508.

The phytoplankton composition of the Chesapeake Bay plume in its distribution over the continental shelf was seasonally studied during March, June and October 1980. These periods also coincided with an unusually low period of water inflow to the Chesapeake Bay. It is feasible to define the bay plume on the basis of phytoplankton populations within the plume which contrasted distinctly from phytoplankton assemblages outside the plume over the shelf. Different assemblages were noted for each seasonal period for the plume and shelf waters. Dominant plume constituents were *Skeletonema costatum* and an ultraplankton component of apparent mixed populations of cyanophycean and chlorophycean species. The plume was characterized by high cell concentrations of phytoplankters, which were mainly small in size and associated with good growth conditions. Ultra- and nanoplankton components were the dominant forms throughout the sampling period. The shelf species were dominated by cocolithophores and netic diatoms. Total cell concentrations generally decreased seaward with patchiness common and a slight increase of cells indicated near the shelf break.

This study was supported in part by the NOAA Northeast Monitoring Program.

OBSERVATIONS ON THE FLOKA OF THE ANTARCTIC. P.M. Mazzeo. Herbarium, U.S. National Arboretum, Washington, D.C. 20002.

The flora of Antarctica, the only polar continent, is greatly restricted by the most severe weather conditions in any area of the world. Temperatures as low as -88.5°C (-127.3°F) and winds in excess of 125 mph are not uncommon in many areas within the Antarctic Circle (66° 30'S). Also, much of the continent is covered by a permanent ice pack.

As a result of these extreme ecological factors, the flora is limited primarily to cryptogamic plants: algae, lichens, mosses, and liverworts. Two flowering plants, *Deschampsia antarctica* (Gramineae) and *Colobanthus quitensis* (Caryophyllaceae), occur only on the Antarctic Peninsula and adjacent islands just beyond the Antarctic Circle.

During a recent trip to the Antarctic, these two phanerogamic taxa were documented with herbarium specimens and photographs now on deposit in the herbarium of the National Arboretum. Each is scattered in exposed rocky soil on or near the shoreline. Fertile material of *Deschampsia* (from the previous season) was documented from Torgerson Island near Palmer Station, 64°46'S; 64°3'W and at Arcotwick Station, King George Is., 62°10'S; 58°28'W. No fertile material could be found for *Colobanthus* (less common than *Deschampsia*) documented from the Arcotwick Station.

GLOBAL DISEASES OF THE ELM. J. A. Micales, R. J. Stipes, J. L. Ratliff and S. R. Lawrence. Dept. Plant Pathology & Physiology, VPI & SU, Blacksburg, VA 24061

Although the pathology of the genus *Ulmus* has been dominated by Dutch elm disease since the 1930's, these trees are subject to a variety of other disorders. These include at least 4 other vascular diseases, including elm yellows (which is caused by a mycoplasma-like organism) and bacterial wetwood, as well as more than 44 leaf spots, 16 cankers, 14 root diseases and 17 wood decays caused by an assortment of fungi, bacteria, nematodes and viruses. Abiotic stresses, such as those induced by mechanical injury, construction damage, exposure to agricultural gases and chemicals, and de-icing salts, are also important factors on most landscape sites.

This is not to diminish the importance of Dutch elm disease, which has gained status as one of the most well-known plant diseases of all times, along with late blight of potato, black stem rust of wheat and chestnut blight. The highly valued American elm is particularly susceptible to the disease, and a portion of America's past has died with these majestic trees. Dutch elm disease can be managed successfully, however, by an integrated system which combines sanitation, vector control, and root graft severance, along with surgical excision of diseased tissues and the injection of systemic fungitoxics.

ARCHITECTURAL ANALYSIS OF APPALACHIAN OAK FORESTS IN SOUTHWEST VIRGINIA. L. Oosterhuis* and T. L. Sharik, Dept. of Silviculture, State Agricultural University Wageningen, The Netherlands, and Dept. of Forestry, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The architectural analysis of forest structure has been developed in the tropics during the past decade. The analysis distinguishes between growing, dynamic and mature, more static stages in forest development. The structure of a mature forest can be described in terms of the presence of sets of trees, i.e., the set of the future, present and past. Each tree is designated to a set on the basis of its potential for expansion in the architectural sense.

In the Brumley Gap study area of southwest Virginia thirteen forest profiles were constructed, two of which are presented in detail. The profiles show that the forests in the area have not yet fully matured. Reconstruction lead to the recognition of two major disturbances affecting the structure of the forests, i.e., logging at the beginning of this century and the chestnut blight (c. 1930). Architectural analyses provide rapid insight into the structure and dynamics of forests. The approach may be of great value in ecological studies and may have important applications in forest and wildlife management.

VEGETATION OF THE BALSAM MOUNTAINS, VA.: A PHYTOSOCIOLOGICAL SURVEY. R. D. Rheinhardt* and S. A. Ware, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185.

A quantitative phytosociological survey was made of the herbaceous and woody vegetation of the Balsam Mountains in southwest Va. These forests were compared with those of other areas with similar elevation and topography and tested for significant correlation between community structure and environmental variables. Altogether, 69 stands were sampled (21 extensively) between 950 and 1750 meters in elevation at various slopes and aspects. Stands were positioned on a 3-axis vegetational mosaic using a Bray-Curtis ordination. Correlational analyses were then performed to compare stand position with the measured environmental variables. Important and/or abundantly represented species were then plotted separately on these ordinations.

Most stands proved to be much more mesic in composition than forests of similar elevations and topography occurring throughout the rest of the Blue Ridge. One fairly extensive community-type of open slopes closely resembles the mixed mesophytic forests of the Cumberlandians and the cove forests of the Great Smokies in vegetational complexity; it differs only in that it occurs at higher elevations and therefore lacks the lower elevational constituents normally associated with the mixed mesophytic forests. In general, species tended to correlate predictably with most environmental parameters; however, a few unanticipated correlates were discovered.

BOTANICAL ASPECTS OF THE GENUS *ULMUS*. J. A. Micales, R. J. Stipes, J. L. Ratliff, and S. R. Lawrence. Dept. Plant Pathology and Physiology, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061

There has been a renewed interest in the taxonomy of the genus *Ulmus* as researchers look for new hybrids and cultivars of elm which are resistant to Dutch elm disease. Elms belong to the family Ulmaceae of the order Urticales; this family contains over 15 genera and 150 species, 32 of which are currently recognized as belonging to *Ulmus*. China is believed to be the center of greatest diversity of the genus. Many new cultivars of elm have been produced by hybridizing various species. American elm is the only tetraploid species in the genus and has not been extensively used in breeding programs. The Dutch have recently produced several new clones - 'Dodoens', 'Lobel', and 'Plantyn' - which are reportedly resistant to both the aggressive and non-aggressive strains of *Ceratocystis ulmi*. Other hybrids have been produced in the United States and include 'Sapporo Autumn Gold' (*U. pumila* X *U. japonica*) and 'Urban' elm (*U. carpinifolia* X *U. pumila*). Huntington elm (*U. X hollandica* 'Vegeta') is England's most resistant elm cultivar and is being planted throughout the country. Zelkova serrata, another member of the Ulmaceae, is being used as a substitute for elm on many American landscapes.

RECONSTRUCTION OF STREAMFLOW RECORDS FROM TREE-RING SERIES IN NORTHERN VIRGINIA. R. L. Phipps, Tree-Ring Laboratory U. S. Geological Survey, Reston, VA 22092.

Monthly values of summer season streamflow on the Occoquan River, 1841-1975, have been estimated from tree-ring series. Seven collections representing six species at sites in northern Virginia were collectively calibrated with existing streamflow data for each month, April through August, 1928-1975. Calibration results were then applied to the tree-ring series to estimate streamflow. Estimates for June, July, and August were judged most reliable. Major mid summer flow minima were reconstructed as having occurred in the early 1870's, the early 1930's, and the mid 1960's. A greater frequency of extreme low flow during summers of individual years is indicated for the entire record than for the most recent 50 years.

OAK REGENERATION DEVELOPMENT AFTER CLEARCUTTING IN THE RIDGE AND VALLEY PROVINCE OF VIRGINIA. M. S. Ross*, T. L. Sharik, and D. Wm. Smith, Department of Forestry, VPI & SU, Blacksburg, VA 24061

Oak stump sprout development was observed two years after whole tree harvesting in southwestern Virginia. Sprout production was investigated as a function of species, vegetation type, and characteristics of the cut tree. Species had an important effect on both the ability of a stump to produce at least one sprout, and the amount of sprout material produced, with *Quercus prinus* exceeding *Q. coccinea* and *Q. velutina* in both cases. The relationship of sprouting with vegetation type was less obvious; types associated with relatively dry conditions appeared to support more dependable oak sprouting, although trends in sprout biomass production were less apparent. Age, diameter, height, and basal area increment of the parent trees were negatively related with the frequency of sprouting, but positively associated with production in those stumps which did sprout. However, variation in the response of individual stumps was high, and R^2 values for production variables were generally in the .2 - .4 range.

PHYTOPLANKTON COMMUNITIES: CONTINUOUS OR DISCRETE EVENTS. Charles K. Rutledge* and H. G. Marshall. Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Kruskal's multidimensional scaling algorithm was applied to selected phytoplankton data to study the variation in seasonal community structures. The primary data base consisted of eight cruises from the northeast coastal waters of the United States. The cruises occurred between October 1978 and July 1980. From this primary data base, two groups of 24 stations each were randomly selected from stations located between 35°N and 39°N Latitude. The two groups represented onshore versus offshore community types using the 30-mile isopleth as a discriminator. This data sampling strategy was chosen to assure pronounced community structural differences between cruises and between distance from shore subgroups. Inter-sample similarity was calculated using Czekanowski's formula on log-transformed cell/liter data. The results are a spatial representation of samples relative to each other using the similarity coefficients as distance functions.

The results illustrate the emergence of different phytoplankton community structures throughout the year, and a different onshore versus offshore response. The lack of noticeable station-point clustering in any dimension by the stations of the seasonal subgroups suggest changes in phytoplankton community structure are continuous as assessed by the MDS technique.

This study was supported in part by the NOAA Northeast Monitoring Program.

UNDERSTORY FORAGE IN CONVERTED LOBLOLLY PINE. *Pinus taeda*, PLANTATIONS OF THE VIRGINIA PIEDMONT FROM TIME OF ESTABLISHMENT TO FIRST THINNING. John J. Scanlon*, and Terry L. Sharik. Dept. Fisheries & Wildlife Sci., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

A double-sampling technique was used to estimate seasonal standing crops of forage in the 0-2 m stratum of second growth, upland hardwood stands, and 2, 5, 11, and 17 year old loblolly pine plantations in the Virginia Piedmont. Samples were taken during the spring (April, May, and June), and fall (September, October, and November) seasons, 1980. Two and 5 year old stands maintained a significantly higher standing crop of forage in all months, when compared with the older stands, and reached maximum levels (190 g/m²) in June.

Eleven year old stands, which had attained crown closure, reached a maximum standing crop of 107 g/m² in June. Seventeen year old stands exhibited maximum forage levels (35 g/m²) nearly equal to those observed in second growth hardwood stands. In early spring, 2 and 5 year old plantations provided the greatest amount of forage (48 g/m² and 40 g/m², respectively), while during late fall, 5 year old plantations maintained the largest standing crop of forage (24 g/m²). Conversion of upland hardwoods to loblolly pine results in elevated forage levels for 8 to 10 years. Commercial thinning, applied at 20-25 years may result in a second pulse of understory production to levels well above those associated with hardwood stands formerly occupying these sites.

THE ELM IN HUMAN HISTORY. R. J. Stipes, J. A. Micales, J. L. Ratliff and S. R. Lawrence. Dept. Plant Pathol. & Physiology, VPI & SU, Blacksburg, VA 24061

From the best sources extant, we estimate that there are about 136,000,000 elms on the earth, in contact with about 25% of the human population. They occur naturally on 4 continents (Europe, Africa, Asia and North America), but have been planted by man in Australia and South America. Elm culture goes back thousands of years, the first written report recorded by Homer. The elm is one of mankind's prized landscape trees, and has also been used for medicine, food, fodder, shelter, protection, religious rituals, tools, vehicles, boats, machines, plows, weapons, coffins, recreation and other amenities. To a forester, elm is wood. To the botanist, it is a complex, dynamic and enigmatic macro-organism. To the chemist it is cellulose and lignin, and to the arborist and nurseryman, it is a source of employment and income. The college alumnus sees it as a campus landmark, the city forester as a headache, the city manager as another problem and the tax collector as another loss. To the farmer, it is fuel and boundary. To the landscaper it is form and beauty. In the history of Western Civilization, there are few trees with such a record of wide use, diversity and affection. In a true sense, the elm is a child of civilization.

SUCCESSIONAL CHANGES IN PIEDMONT VIRGINIA FORESTS. M. J. Scanlon. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284

In 1976 and 1979 five Virginia Forest sites were intensively sampled to determine the direction and magnitude of change during post-logging succession. Although there are compositional differences between these forests and those sampled by Osting in North Carolina (1942), the stable, terminal community on the uplands in Piedmont, Virginia is similar to the North Carolina white oak-hickory type.

The recorded changes in the tree populations demonstrate that logging encourages or discourages growth and reproduction among the species. These alterations have been viewed as evidence of competitive ability and successional pattern mapped accordingly. However, when viewed as evidence of either competitive or stress-tolerance strategies the predicted outcome of succession is different.

THE VASCULAR FLORA OF THE KERSEY-CRUMP CREEK WATERSHED, HANOVER COUNTY, VIRGINIA. E. R. Smith and William S. Woolcott. Dept. of Biology, Univ. of Richmond, Richmond, Va. 23173.

A floristic survey was conducted in the Kersey-Crump Creek watershed, Hanover County, Virginia from spring 1978 through summer 1980. This upper Coastal Plain area (42 km²) near the fall line yielded 514 species of vascular plants, representing 334 genera and 113 families. Four hundred and seventy-nine county records were established. *Panax trifolium*, colonizing a rich wooded creek bottom, was the only plant rare to Virginia. Voucher specimens are deposited in the herbaria of the University of Richmond, Virginia, and the College of William and Mary, Williamsburg, Virginia.

DESCRIPTIVE VEGETATIONAL STUDIES IN THE CENTRAL COASTAL PLAIN OF VIRGINIA. Stewart A. Ware, Dept. of Biology, College of William and Mary, Williamsburg, VA 23185.

Forest stands sampled by the Bitterlich and/or point-centered quarter method have been used to construct separate Bray-Curtis ordinations for small stream swamps and uplands. Red maple, ash, and American elm dominate in wetter, more fertile, less acid swamps. Water oak, willow oak, sweet gum, and (in selectively cut sites) American hornbeam dominate in less moist, less fertile, more acid swamps. Loblolly pine, white oak and beech fail to correlate with soil chemistry, but reflect increasing age of the stand since cultivation. Beech dominance was not correlated with steep slopes. Virginia pine and tulip tree importance are related to past partial disturbance of loblolly pine or pine-white oak stands, respectively. Hickories are also more important in disturbed hardwood stands. Sweet gum, coming in abundantly under loblolly pine, rarely reached canopy size in uplands. Forests were rather different in composition from Piedmont forest stands, and showed their closest relationship to the beech-white oak end (as opposed to the laurel oak-sweet gum-hickory end) of the Southern Mixed Hardwood Forest gradient of the southeastern Coastal Plain.

VASCULAR PLANTS IN SEASHORE STATE PARK NOT INCLUDED IN FRANK E. EGLER'S CHECK LIST (1942). Joan B. Wright*, Judith L. Kernell*, and Gerald F. Levy. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

This paper reports vascular plant species found growing within the boundaries of Seashore State Park, Virginia Beach, Virginia, that were not reported by Frank E. Egler (1942) in his Check List of the Ferns and Flowering Plants of the Seashore State Park. The study is based on collections made from a wide diversity of sites throughout the park and along a transect which extended from the southern park boundary at Long Creek to the northern park boundary at Chesapeake Bay. Of the 203 species of fall and perennial flora collected, 51 species encompassing 39 genera belonging to 31 families were found not to be on Egler's check list. Field work was conducted during September 1980 through April 1981. Continuing collections through the spring and summer may yield noteworthy additions.

COMPARISON OF DECAY RATES OF CONFINED VERSUS UNCONFINED LITTER IN THE GREAT DISMAL SWAMP. F.K. Yates* and F.P. Day, Jr. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Data collected from two previous years suggests that both frequency and duration of flooding have a strong influence on decomposition and nutrient turnover rate (N, P, K, Ca, & Mg) in the swamp. This study was executed in order to 1) obtain a third year of data for evaluating year to year variation, 2) to compare litter bag technique of rate determination with the unconfined leaf pack technique, and 3) to compare both of these methods with a pure cellulose standard for decomposition. A secondary objective is to qualitatively evaluate soil fauna coponents. 1980 has been the driest year on record for south-eastern Virginia. Data are compared with the two previous "normal" years and an assessment of drought impact in the swamp is noted.

Chemistry

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

SYNTHESIS AND PROPERTIES OF THE SODIUM METABISULFITE-SODIUM FORMATE COMPLEX. R. L. Ake, D. M. Oglesby, Dept. of Chem. Sciences, Old Dominion University, Norfolk, VA 23508 and D. Snyder, Va. Chem. Inc., Portsmouth, VA.

Ertl and coworkers reported the formation of a double salt of sodium metabisulfite and sodium formate, having the formula $\text{Na}_2\text{S}_2\text{O}_5 \cdot \text{NaHCO}_2$, during the synthesis of sodium dithionite by the so called formate process (G. Ertl, V. Kiener, W. Ostertag, and Gerd Wunch, *Angew. Chem. Int. Ed. Engl.* 18 (1979), No. 4).

A reproducible method for the synthesis of the double salt has been developed in our laboratory (Virginia Chemicals, Inc.) which gave a 24% yield of the salt having the formula $\text{Na}_2\text{C}_2\text{O}_4 \cdot \text{NaHSO}_2$. The analysis for $\text{Na}_2\text{S}_2\text{O}_5$ was 72.14% vs a calculated value of 73.62.

The x-ray diffraction powder pattern was determined and found to be the same as that reported by the German workers. Differential thermal analysis shows an endothermic decomposition at 122°C. The electron spin resonance (ESR) spectrum as a function of temperature was recorded and revealed only a weak signal of unknown origin at 80K. However, a strong, relatively isotropic ESR signal appeared as the sample was warmed above 320°K. The temperature dependence and spectral characteristics of the signal were compared with those from $\text{Na}_2\text{S}_2\text{O}_4$ and $\text{Na}_2\text{S}_2\text{O}_5$.

THE PREPARATION OF 9-PHENANTHRENETRIBUTYLAMMONIUM METHANESULFONATE. D.W. Armstrong, W.S. Ashe, E.S. Dummitt, III, C.H. Crestwood, M.E. Robson, J.K. Shillington and S.W. Snyder, Department of Chemistry, Washington and Lee University, Lexington, Va. 24450

It is known that many aromatic compounds are carcinogenic and/or cancer drugs. It is thought that this may involve the stacking of the aromatic ring systems of the bases in DNA and RNA to form a hydrophobic core in the helix. This is surrounded by the ribo-phosphate strands coated with protonated amines called histones which offset the negatively charged phospho groups.

We are attempting to synthesize a series of largearomatic quaternary ammonium salts which we hope may insert themselves into this hydrophobic-hydrophilic system with the result that the core of the helix will be altered and replication interrupted, perhaps interfering with the cells' growth.

This paper deals with the synthesis and modification of aromatic tributylammonium salts with emphasis on a particular salt derived from phenanthrene.

BIOCHEMICAL ANALYSIS OF HUMAN SEMINAL FLUID. J. Ayub and J. H. Yuan, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, Va., 23508

Human semen is emitted at the time of ejaculation and is a viscous secretion of the primary and secondary male genital glands. The secretion is composed of spermatozoa and seminal fluid. Seminal fluid serves as a medium for transport of spermatozoa, and composed of the secretions from prostate, seminal vesicle and epididymis. Prostatic fluid is characterized by a high citric acid and acid phosphatase as well as absence of reducing sugars. The seminal vesicle secretion is characterized by its high concentration of reducing sugars, protein and prostaglandins. An absence or low level of any of these constituents may suggest dysfunction or obstruction of the specific accessory gland. At present, there is no single criterion for differentiating fertile and infertile male. We have thus set forth to study the normal range of fructose, protein, glycerolcholine, acid phosphatase and citric acid levels in normal fertile male. The results of these studies will be presented.

INVESTIGATION OF ALTERED DIET ON MEMBRANE FATTY ACID PROFILE OF EHRICH ASCITES TUMOR CELLS. T. Baldwin and L. Wolfenbarger, Jr. Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

This paper represents a preliminary study of the fatty acid profiles of Ehrlich ascites tumor cells grown in mice on different dietary supplements. Membranes of tumor cells grown in mice on a diet high in saturated fatty acids (coconut oil supplement) show a higher percentage of saturated and monosaturated fatty acids than those membranes from tumor cells grown in mice on a diet high in unsaturated fatty acids (sunflower seed oil supplement).

The fatty acid profiles of membranes from these two groups are correlated with a control tumor cell membrane preparation isolated from ascites cells grown in mice on a nonsupplemented diet. Experimental procedures consist of membrane lipid extraction, silicic acid column chromatography, derivatization and analysis on gas/liquid chromatograph.

NEUTRON ACTIVATION ANALYSIS AT THE UNIVERSITY OF VIRGINIA.
P.E. Benneche* and B.L. Shriver. Dept. of Nuclear Engr. & Engineering Physics, Univ. of Va., Charlottesville, VA 22901.

The University of Virginia Department of Nuclear Engineering and Engineering Physics owns and operates a two megawatt research reactor. The reactor is used for research, graduate and undergraduate thesis projects and student laboratories. Some special classes and research by students and professors at other universities are also conducted with grants through the Department of Energy's Reactor Sharing Program.

Neutron activation analysis is the process by which a non-radioactive sample of unknown composition is placed in a neutron flux which transforms a small amount of each element in the sample into radioactive isotopes. The quantity of each isotope produced is established by the amount of each element present in the sample, the level of the neutron flux and the irradiation time. Each of the isotopes emits characteristic gamma rays by which the elements in the sample can be identified. When the sample is counted on sensitive solid state radiation detectors the precise amount of each element can be determined.

At the University of Virginia we are currently able to analyze a sample for over 50 different elements. Examples of the application of neutron activation analysis to research projects will be discussed. The use of the neutron activation analysis facilities at the University of Virginia is encouraged.

STUDIES OF APOLIPOPROTEINS FROM HUMAN HIGH DENSITY LIPOPROTEIN. C. Chin and J. H. Yuan, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, Va., 23508

Over the last several years an intensive investigation has focused on the identification of risk factors for the development of premature atherosclerosis. Recent research suggested a negative correlation between high density lipoprotein (HDL) cholesterol in human plasma and risk of premature heart disease. Apoproteins, ApoA-I and ApoA-II are two major protein constituents of HDL. ApoA-I was reported to activate lecithin cholesterol acyltransferase (LCAT). However, the function of ApoA-II still unclear. Our research focus on the study of the effect of ApoA-II modulation of HDL composition. We also attempted to develop a method suitable for clinical laboratory for routine analysis of HDL subclasses, HDL₂ and HDL₃. The detail of the method will be presented.

(Supported by a grant from Va Affiliate of American Heart Association)

STUDIES ON ANTITUMOR AGENTS WHICH INHIBIT RIBONUCLEOTIDE REDUCTASE ACTIVITY IN EHRLICH ASCITES TUMOR CELLS. K. Friele* R. L. Williams, L. Wolfinbarger. Dept. Biology, Old Dominion University, Norfolk, Va. 23508

A variety of α -(N)-heterocyclic thiosemicarbazones have been synthesized and evaluated for antineoplastic activity in transplanted animal tumor systems. The generally accepted mechanism of action suggests that the α -(N)-heterocyclic thiosemicarbazones block DNA synthesis in tumor cells by inhibiting ribonucleotide reductase, either by chelation of the compound with the enzyme dependent ferrous ion, or through a preformed metal chelate which inhibits reductase activity. The objective of this paper is to describe the evaluation of a series of new semicarbazones and thiosemicarbazone derivatives of the di-2-pyridyl and 1,8 diazfluorene ring systems. Our preliminary evaluation of these agents against transplanted Ehrlich ascites tumor cells in mice have shown them to exhibit a relatively high level of activity as compared to certain standard α -(N)-heterocyclic formyl thiosemicarbazones. This preliminary in vivo activity has been complemented by specific enzyme studies which have shown that these systems do in fact exhibit the potential to inhibit ribonucleotide reductase activity.

A CONVENIENT PROCEDURE FOR THE SYNTHESIS OF RADIOLABELED PEPTIDES. J. Castellano and L. Wolfinbarger, Jr., Dept. Biol. Sci., Old Dominion Univ., Norfolk, Va. 23508

Traditional procedures for the synthesis of small peptides employ deblocking steps which may derivatize the peptide in addition to deblocking it. The procedure described here utilizes benzyl esters of carboxyl groups on peptides and amino acids and carbobenzoxy (CBZ) - amino acids with the traditional coupling reagent dicyclohexylcarbodiimide (DCC). The advantage lies in subsequent simultaneous deblocking of both protective groups by use of formic acid/methanol as the solvent and palladium black as the deblocking agent.

POLYAMINE-NUCLEOTIDE INTERACTIONS: LEAST SQUARES ANALYSIS OF A NON-LINEAR SYSTEM. L. C. Clary, W. H. Voige, and J. J. Leary*. Dept. of Chemistry, James Madison University, Harrisonburg, Va. 22807

An improved mathematical model for the calculation of polyamine-nucleotide formation constants is presented. It will be demonstrated that the basic equations are always non-linear in coefficients and, in general, are higher order in polyamine concentration. Further, it will be demonstrated that approximations can be made, and that new equations which are linear in coefficients can be written. Finally, it will be shown that these equations are functionally correct and that the formation constants obtained using this approach often differ significantly from those obtained using earlier methods.

THE ANALYSIS OF S-ADENOSYLMETHIONINE AND S-ADENOSYLMETHIONINE IN NORMAL AND NEOPLASTIC CELLS. K. E. Godburn and T.O. Sitz, Dept. of Chemical Sciences, Old Dominion University, Norfolk, VA. 23508.

Altered patterns of methylation have been shown in both ribosomal and transfer RNA isolated from cancer cells. In contrast to the elevated activity of the methyltransferases responsible for this modification, hypomethylation appears as a general characteristic. The endogenous levels of S-adenosylmethionine (SAM) and S-adenosylhomocysteine (SAH) are important in relationship to their role substrate and product of the transmethylation reactions. Rat cells of high passage were characterized by an increase in the ratio of SAM to SAH in addition to a decrease in the quantities of both compounds. In human cells the concentration of SAM was increased in neoplastic cells. The ratio of SAM to SAH was inversely related to the methylation levels in 5.8S rRNA suggesting that the levels of SAM and SAH do not control RNA methylation, but rather the methylation levels influence the SAM and SAH levels.

LARGE SCALE ISOLATION OF 5.8S rRNA FROM MAMMALIAN TISSUE FOR CONFORMATIONAL STUDIES. C. D. Howell and T. O. Sitz, Chemical Sciences Department, Old Dominion University, Norfolk, VA 23508.

The mammalian 5.8S rRNA contains two 2'-O-ribose methylated positions in its sequence. Position 14 contains a partially modified uridine (U_0G) which was found to vary from 0.15 to 0.85 molar amounts in a variety of tissues with the lowest yields in cancer cells. The U_0G modifications occur as a late cytoplasmic modification which has an effect on the conformation of the 5.8S rRNA. This may have important consequences for how the molecule functions in protein synthesis. Methods have been developed to isolate large amounts (mg. amounts) of 5.8S rRNA for conformation studies. Since 5.8S rRNA is hydrogen bonded to the larger 28S rRNA molecule, it can be partially purified by differential salt precipitation. Further purification was achieved by melting the 28-5.8S rRNA complex and removing the larger RNAs by salt precipitation. Final purification was accomplished by gel permeation chromatography on S-300 sephacryl. The 5.8S rRNA peak was then allowed to dimerize and reappplied to the column to remove co-migrating contaminants.

Optimization of Rare Earth Chlorides in Acetal Formation. Susan A. Howell*, Junaid A. Siddiqui, Raphael M. Ottenbrite. Dept. of Chemistry, Va. Commonwealth Univ., Richmond, VA 23284.

We have investigated the scope and limitations of utilizing trichlorolanthanide compounds in acetal formation of substituted benzaldehydes. It was observed that higher acetal yields were obtained for those aldehydes with para-substituted electron-withdrawing groups such as p-nitro (97%) compared to the unsubstituted benzaldehyde (85%). Strong electron-donating groups such as para-methoxybenzaldehyde were observed to affect a significant reduction in acetal formation.

Generally, the reaction went to completion in 15 minutes and yields were not appreciably increased with extended reaction times. An exception to this was mediumium trichloride with para-methoxybenzaldehyde, which showed no observable reaction after 15 minutes, but an 8% conversion after 18 hours.

The activity of the catalyst changed with time. The greatest effectiveness was in the first 2 or 3 days and approximately a 10% decrease was observed for each day after. It was also observed that the effective concentration of catalyst varied significantly with the substrate used. The present data seems to indicate that there could be more than one mechanism involved in the process.

DETERMINATION OF N,N' -DIPHENYLGUNNINDINE (DPG) IN BIOLOGICAL MEDIA BY HIGH PRESSURE LIQUID CHROMATOGRAPHY (HPLC). E. S. Hunter, III and F. E. Scully, Jr., Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508 and M. A. Bampton, Department of Biology, Norfolk State Univ., Norfolk, VA 23504.

DPG is used as an accelerator in processing rubber; the necessity of its determination has been shown as DPG has been found to be mutagenic by Ames Assay.

Using a solution of 70% Sodium Hypochlorite and 30% Ethanol as a TLC spray is a novel method for the qualitative determination of >10 micrograms of DPG.

HPLC analysis using UV detection is sensitive for the determination of 1×10^{-7} grams of DPG. Since a more sensitive method was required and since DPG itself does not appreciably fluoresce, fluorescent labelling was next attempted. Derivatization with o-phthalaldehyde and ninhydrin or condensation with dibenzoylmethane and sodium p-toluenesulfonate all failed to yield a fluorescent product.

Reaction with 1-dimethylamine-naphthalene-5-sulfonyl chloride (DANS-Cl) produces a fluorescent product when reached in 10-100 molar excess with a Sodium Bicarbonate saturated DPG standard solution (Details will be given).

Urine was collected from rats chronically treated with DPG in their drinking water and from control rats. DPG was extracted from the urine, and diluted to volume, saturated with sodium bicarbonate and reached with Dans-Cl.

THE FUJITA-BAN METHOD FOR PREDICTING DRUG ACTIVITY: A SIMPLE CHEMICAL EXAMPLE. A. L. Johnston, C. Nguyen, D. S. Amenta, and J. J. Leary*, Dept. of Chemistry, James Madison University, Harrisonburg, VA 22807

Many predictive methods have been used by the pharmaceutical industry for the estimation of drug activity. The approach of Fujita and Ban is one such method which is both readily understood and easily used. This method will be described from both a conceptual and a mathematical viewpoint. A simple, purely chemical example will be presented and developed for the prediction of pKa values of hydroxyl substituted benzoic acids. Results will then be presented for the application of the Fujita-Ban method to the prediction of pKa values for a much larger and more general set of benzoic acids. The results illustrate the utility of this method for predicting chemical, as well as biological activity.

A COMPUTER DETERMINATION OF 2V OF ANTHRACENE FROM EXTINCTION DATA. Maureen M. Julian, Dept. of Geological Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

In binomial crystals, measurement of the angle between the two optic axes, 2V, is constant for a given crystal, at a given temperature, and for a given wavelength. A study of the optical properties of anthracene was done because of conflicting results in the literature and because recently developed techniques (Bloss 1981)

introduce computer and statistical methods into the practice of optical crystallography permitting greater accuracy. The work was complicated by the fact that the anthracene crystal rapidly dissolves in immersion media. Data was completed on four separate crystals, three at 540nm and one at 900 nm. The data was analyzed by the Bloss-Rees-Rohrer program "excalib" using Joel's equation to find the optic axes and refinement was done by least squares to calculate an accurate 2V. Crystalline refractivities were calculated from the refractive indices. The molecular refractivities were calculated from a combination of the crystalline refractivities and information on the packing and shape of the molecules.

Bloss, F.D. "The Spindia Stage: Principles and Practice" CUP 1981

DETERMINATION OF NIOBIUM AND OTHER TRACE ELEMENTS IN SELECTED HUMAN TISSUES. P. M. Kaczaral, G. C. Grant and C. Djordjevic, The College of William and Mary Research Campus (Newport News) and Williamsburg Campus, VA.

Niobium lies just under vanadium and next to molybdenum in the periodic table. Both of these are trace elements essential to life. A few reports have indicated ppm levels of niobium in certain tissues, which would be consistent with an essential role as an enzyme constituent.

Accordingly three analytical methods for the determination of niobium in human tissues were investigated: graphite furnace atomic absorption spectrophotometry, flame atomic absorption and Proton-Induced X-ray Emission (PIXE). All attempts by furnace atomic absorption were unsuccessful including matrix modification procedures (no furnace method has been published for Nb). Flame atomic absorption methods were reproducible, but detection limits were only ca. 10 ppm - inadequate for tissue analysis.

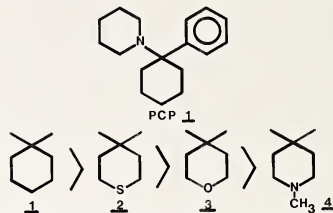
PIXE methods were reproducible and gave typical detection limits of 0.1 µg/g tissue (dry weight). Recoveries of niobium spiked bovine liver (NBS SRM 1577) were 90 percent and results for other trace elements were in accord with published values. In kidney, aorta, brain and spleen niobium was less than 0.10 µg/g in contrast with previous published values of 4.74, 6.23, 1.61 and 1.36 µg/g respectively.

DETERMINATION OF URINARY OXALATE WITH A POTENTIOMETRIC ENZYME ELECTRODE. R.K. Kobos, J.A. Morrissey*, and P. Burnet*. Dept. of Chemistry, Virginia Commonwealth Univ., Richmond, VA 23284.

A highly selective enzyme electrode system for the determination of urinary oxalate has been developed. The oxalate sensor utilizes oxalate decarboxylase chemically immobilized on a carbon dioxide gas-sensing electrode, which measures the CO_2 produced by the enzymatic reaction. The response of the system is linear with the logarithm of the oxalate concentration between 2×10^{-4} and 1×10^{-2} M with a slope of 57-60 mV/decade. The lower limit of detection is 4×10^{-5} M, which is below the normal range of urinary oxalate levels. There was no decrease in this response after one month of daily use. Selectivity studies indicate that the sensor is not affected by the normal constituents of urine and therefore can be used to directly measure oxalate in urine samples. Recovery studies of oxalate added to human control urine samples gave an average recovery of 97.7%. Artificial urine samples were analyzed with an accuracy and precision of 5 to 6%. (Aided by a grant from Research Corporation).

HETEROCYCLIC ANALOGS OF PHENCYCLIDINE. D. McKenney and R. L. Williams. Dept. of Chemical Sciences, Old Dominion University, Norfolk, VA 23508.

Phencyclidine (PCP) 1 has become one of the nation's leading drugs of abuse. In an effort to investigate PCP's structure activity relationship in terms of its receptor interaction, this laboratory has synthesized a series of heterocyclic analogs 2, 3, and 4. These analogs have been evaluated in terms of their gross behavior effects and ability to produce motor impairment using the Screen Test. Though none of the analogs were as potent as PCP the order of activity in this series has been established.



THE CHEMISTRY OF GALLSTONES. Joyce D. McKnight* and Maureen M. Julian, Hollins College, VA. 24020

Samples of gallstones were collected from the pathology departments of three Roanoke, Virginia hospitals. Stones were tested for cholesterol, which is found in more than 75% of the stone, by dissolving a small amount of the stone in chloroform and a few drops of H_2SO_4 , which will give a red ring around the bottom of the test tubes if the test is positive.

Calcium carbonates can be present in three forms: Calcite, Aragonite and Vaterite in decreasing stability. The HCl test was used to test for carbonates. Metal carbonates such as Calcium, Magnesium, Lead, Zinc, Cobalt and Lead. Calcium Phosphate in the form of Apatite and Whitlockite are crystallized from bile and are in the form of calcium salts.

All stones contain amorphous organic matrix, which is obtained by placing the stone in a 4% solution of Na^+ salt of chondroxycholic acid at room temperature, it gradually takes on a fluffy appearance as the matrix becomes exposed and the crystalline material dissolves.

Infrared, UV, and X-ray diffraction techniques were also used in analysis.

SYNTHESIS AND THERMOCHEMICAL STUDIES OF LITHIUM DITHIONITE. D. R. Mitchell and D. M. Oglesby, Dept. of Chemical Sciences, Old Dominion University, Norfolk, VA 23508.

Two methods for the synthesis of lithium dithionite have been developed. Both are based on the reduction of sulfur dioxide by lithium formate in a methanol-water solution. One method, based on U.S. patent #3, 411, 875, involved the addition of sulfur dioxide to a methanol-water solution of lithium hydroxide to first form lithium sulfite. This solution was then reacted with aqueous lithium formate. The second method, based on patent #2, 010, 615, involved the reduction of lithium formate in a methanol-water mixture of lithium formate and lithium carbonate.

The hydroxide based method yielded 92% pure lithium dithionite, based on the iodometric titration of the formaldehyde sulfoxalate of the dithionite ion. Differential thermal analysis was used to compare the decomposition behavior to that of sodium dithionite. X-Ray powder patterns and infrared spectra were also taken.

THE TEMPLATE SYNTHESIS OF MERCAPTOETHYL-AMINE-N,S-DIACETATE COMPLEXES. S.M. Ortel¹, Substations Test Dept., Potomac Electric Power Company, Washington, D.C. and T.A. Donovan*, Dept. of Chemistry, Buffalo State College, Buffalo, N.Y.

The technique of "template synthesis" was employed to prepare the first coordination compounds incorporating an open-chain quadridentate ligand which utilizes three different types of donor atom. Condensation of cysteamine-N-acetic acid with chloroacetic acid in an alkaline environment in the presence of appropriate metal ions produced neutral tetracoordinate complexes of mercaptoethylamine-N,S-diacetate with Mn(II), Fe(II), Co(II), Ni(II), Cu(II), and Zn(II). These complexes were characterized by elemental analysis and by measurement and interpretation of their ultraviolet, visible, and infrared spectra. Magnetic moment determinations were also made for some of the complexes.

DETERMINATION OF COPPER AND ZINC IN HUMAN SERUM USING POLARIZED ZEEMAN-EFFECT FLAME ATOMIC ABSORPTION SPECTROSCOPY. P. A. Plehan and A. Munyani. Dept. of Chem. Sci., Old Dominion University, Norfolk, VA 23508.

Correction for nonanalyte absorption is a major problem encountered when using atomic absorption spectroscopy (AAS) for trace metal analysis in biological matrices. Recently, a background correction technique based on the Zeeman effect (1) has been designed for use in flame AAS.

We have determined zinc and copper in a tenfold dilution of human serum. Analyses were performed using a Polarized Zeeman-Effect Atomic Absorption Spectrometer (N.S.A. Hitachi, Model 180-70) equipped with a Zeeman burner accessory.

Copper determinations were made by aspirating the diluted specimen into an air-acetylene flame (2.4 L/min fuel:9.4 L/min oxidant) and measuring the absorption at 324.7 nm. Replicate analyses of a pooled serum specimen yielded an RSD of 1% (124.3 ± 1.0 ug/L, N = 10). Forty-seven specimens, analyzed using standard additions and comparison to an aqueous calibration curve, gave a linear regression line, $Y = 0.973 X + .054$, and a correlation coefficient (r) of 0.999.

Zinc analyses utilized an air-acetylene flame (2.0 L/min: 9.4 L/min) at the 213.9 Zn line. Within-run RSD was found to be 1.7% (1.293 ± 0.021 mg/L, N = 10). Comparison of standard additions and direct determinations gave a regression line, $Y = 1.02 X - 2.53$, and $r = .989$.

1. Kotzumi et al., #504, Pittsburgh Conference, March, 1980, Atlantic City, NJ.

TOWARD 1,6,10-OXO[4.4.4]PROPELLA-2,7,11-TRIENE. M.A. Pleva, J.K. Shillington, D.V. Young, Department of Chemistry, Washington and Lee University, Lexington, Va. 24450.

The current entry to the C₁₄-propellane series is via the *cis*-4a,8a-bisbromomethyldecalin as developed by Ginsberg et al in the late 1960s. At that time an investigation was under way at our laboratory to synthesize such a propellane via a Diels-Alder condensation between an activated $\Delta^9,10$ octalin and a butadiene such as 1-acetoxy-1,3-butadiene. This project has waited upon the actual synthesis of a suitably activated octalin which will act as the dienophile. A number of procedures have been attempted, but most of the procedure and facilities are beyond the capacity of the small undergraduate laboratory.

We are currently exploring the production $\Delta^9,10$ octalin-1,5-dione from the decalin-1,5-dione by the formation of a 9,10-hydrohalo intermediate followed by elimination of HX due to steric relief coupled with the formation of a conjugated π -system. Formation of $\Delta^9,10$ octalin-1,5-dione in large enough amounts to be used as the dienophile in the Diels-Alder condensation is one goal, which may provide an elegantly facile entrance into the C₁₄-propellane series.

CONFORMATIONAL ISOMERS OF MAMMALIAN 5.8S RIBOSOMAL RNA. D. Smith and T. O. Sitz, Chem. Sciences Department, Old Dominion University, Norfolk, VA 23508.

5.8S rRNA occurs in the large subunit of the eucaryote ribosomes and is known to form specific associations with 28S rRNA, rRNA, ribosomal proteins and methyl transferases. The mammalian 5.8S rRNA contains two 2'-O-ribose methylated positions in its sequence. Position 14 contains a partially modified uridine (UmG) which was found to vary from 0.15 to 0.85 molar amounts in a variety of tissues with the lowest yield in cancer cells. When whole cell RNA was separated on polyacrylamide gels multiple bands of 5.8S rRNA were observed, consisting of a set of three intense bands followed by a set of three faint bands. Since oligonucleotide mapping does not show any significant sequence variation between the three intense bands, it is believed that the fastest of the three represents a compact conformation and the slower bands more open conformations. The fastest band is unmethylated, the middle band is approximately 25% methylated, and the slowest band is approximately 75% methylated. When the six bands of 5.8S rRNA are eluted from the gel and then electrophoresed under denaturing conditions, the material from the three intense bands migrates as a single band, and the material from the faint band migrates more slowly as a single band. These faint bands may represent different conformations of an elongated 5.8S rRNA sequence (i.e. an aberrant processing fragment or a precursor).

INTERFACING OF A PDP-11 MINICOMPUTER WITH A BECKMAN 25 SPECTROPHOTOMETER. J. R. Thweatt*, and J. D. Van Norman, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508.

The interfacing of the PDP-11/10 minicomputer with a Beckman 25 spectrophotometer resulted in an on-line computer system which could be applied to enzyme kinetics studies.

An analog voltage signal, corresponding to absorbance, was tapped from the Beckman 25, via its accessory connector, amplified, and fed into the analog-to-digital converter of the AR11 interface. The analog voltage signal was converted to digital data and stored in data files using the THRU program, under control of the PDP-11/10 minicomputer.

FORTAN data processing programs were used to: open and read each digital data file and calculate absorbances; plot absorbance curves; calculate substrate concentrations and determine linearity of absorbance curves in calculating velocities; determine kinetic parameters by using linear least squares analysis of linear rearrangements of the Michaelis-Menten equation; study various types of inhibitors.

DUMAS AND PREGL REVISITED WITH MASS SPECTROMETRY. Billy T. Upchurch, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, VA. 23508 and George M. Wood*, NASA Langley Research Center, Hampton, VA. 23665.

The analytical methodology used in the analysis of organic compounds for hydrogen, carbon, and nitrogen elemental composition was developed by Dumas in 1833 and later improved by Pregl in 1911. These authors developed the methodology under operative temperature conditions which assured complete conversion of the compound to carbon dioxide, water and nitrogen which were subsequently measured gravimetrically and volumetrically. We have utilized mass spectrometry in examining the conversion process for a number of chemical compounds as a function of temperature and with the use of isotope labels have elucidated one unambiguous mechanism. Results of these studies are discussed both in terms of these chemical processes and applicability toward more selective analytical methodology.

ELECTRON PARAMAGNETIC RESONANCE SPECTROSCOPY OF OXO-Mo(V) TETRAPHENYLPORPHYRIN COMPLEXES. J. Topich and N. Berger, Dept. of Chemistry, Virginia Commonwealth Univ., Richmond, VA 23284.

Electron paramagnetic resonance (EPR) spectroscopy is a technique which is useful in probing the electronic structure of paramagnetic transition metal complexes. Molybdenum is an important transition metal in both industrial and biological catalytic reactions. We have synthesized a series of oxo-Mo(V)-p-substituted-tetraphenylporphyrin complexes (OMo(V)-p-x-TPP; x = CH₃, OH, H₂F, Cl, Br). Tetraphenylporphyrins were chosen as ligands so that the coordination geometry and stereochemistry of the Mo complexes is well defined. The UV-visible spectra for OMo(V)-TPP complexes are indicative of the species present in solution. The solution behavior of these complexes will be discussed. Shifts in the energies of the electronic transitions are seen when the ligand substituent is changed. In addition, isotropic and anisotropic EPR spectra for the Mo(V) complexes are presented. Anisotropic spectra are obtained in a frozen liquid crystal solvent. The liquid crystal EPR results allow for the unambiguous assignment and calculation of g_{||} and g_⊥, especially when there is overlap between them. The electronic structure of the Mo(V) complexes are discussed in light of the EPR results.

PLANAR SYMMETRY IN PERIODIC DESIGNS. Anna Mary Van Buren* and Maureen M. Julien, Dept. of Chemistry, Hollins College VA, 24020

The study of two-dimensional planar groups is important in the understanding of surface chemistry, as a manageable educational aid to understand the synthesis of symmetry, both two and three dimensions, and as a purely aesthetic treat. This work was inspired by M.C. Escher's ingenious use of interlocking characters to fill two dimensional space. Escher, an artist, never completed designs for all seventeen of the planar groups. The goal of this project is to complete plates for all of the seventeen space filling possibilities. The artistic and mathematical demands are intermeshed. A suitable motif is selected cunningly designed so that the generated and inserted symmetry elements all appear equally plausible. These are carefully drafted onto an appropriate grid. A contrasting "negative" space is generated which must be filled with an appropriate complementary interlocking design.

1. Caroline H. MacGillivray, Fantasy and Symmetry, The Periodic Drawings of M. C. Escher, Harry N. Abrams, Inc. NY 1976.

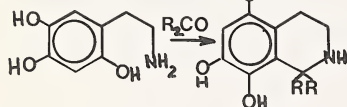
Mount St. Helens: THE VOLCANO AND THE ASH. J. P. Wightman, Betty Beck*, and Yoonok Kang. Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

An analysis of ash collected following the eruption of Mount St. Helens is detailed. Seven samples collected from six locations in Washington were analyzed by scanning electron microscopy/energy dispersive analysis of x-rays (SEM/EDAX) and electron spectroscopy for chemical analysis (ESCA). Data reported in the literature demonstrates that the ash with particle size $< 3.5 \mu\text{m}$ constitutes $< 2 \text{ wt } \%$ of the total ash. Further, it has been demonstrated that the ash is similar in composition to dacite. The SEM photomicrographs show a broad size distribution. Major elements detected by EDAX were Al, Ca, K, Na, Si; minor elements were Fe, Mg and Ti. The following major elements were detected by ESCA: Al, Na, O, Si; minor elements included Ca, Cl, K, and Mg. Good agreement was obtained for the Al/Si, Na/Si and Ca/Si elemental ratios determined by ESCA and those ratios reported in the literature. Cl was detected as a surface component of the ash but not S although high concentrations of both H_2S and SO_2 were measured in the atmosphere following eruption.

CONDENSATION PRODUCTS OF 6-HYDROXYAMINE WITH VARIOUS CARBONYL COMPOUNDS. R. L. Williams and R. L. Hudkins, Dept. of Chemical Sciences, Old Dominion University, Norfolk, VA 23508.

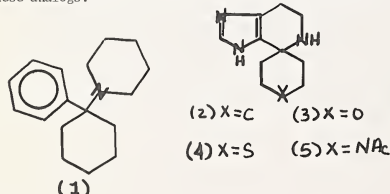
6-Hydroxydopamine (6-OHDA) is a very potent neurotoxin demonstrating remarkable site selectivity and neuronal toxicity toward the adrenergic nerve system. In 1977 Osswald noted similar characteristics in the action of the tetrahydroisquinoline (TIQ) derived from the condensation of adrenalin with acetaldehyde, and 6-OHDA although the TIQ was a much less potent neurotoxic agent.

Recently, we have been working on incorporating these two unrelated systems into one molecule, possible increasing both site selectivity and neuronal toxicity. Pictet-Spengler reaction of 6-OHDA and various carbonyl compounds should give rise to the ortho cyclized heterocyclic TIQ analogue of 6-OHDA. Ring closure taking place ortho to the activating hydroxyl function.



NOVEL SPIROCYCLO-4, 5, 6, 7-TETRAHYDROIMIDAZO [4, 5-C] -PYRIDINES. R. L. Williams and Sandra Neergaard, Dept. of Chemical Sciences, Old Dominion University, Norfolk, VA 23508.

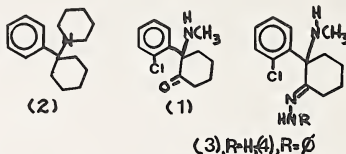
In an effort to prepare a series of PCP (1) analogs, we have synthesized a number of novel spirocyclic tetrahydroimidazo [4, 5-C] pyridines (2-5). These compounds were obtained by the condensation of histamine free base with various heterocyclic analogs of cyclohexanone in reflecting n-butanol. We will discuss the synthesis and characterization of these new compounds together with an evaluation of their potential biological activity. More of these compounds were found to exhibit PCP like activity, however, some mild analgesic activity was observed with several of these analogs.



KETAMAZONE: ITS SYNTHESIS AND PROPERTIES.

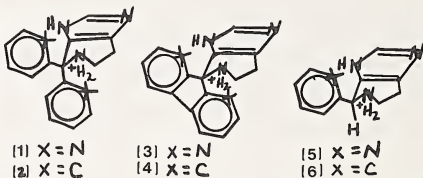
R. L. Williams and Ann Booth, Dep't. of Chemical Sciences, Old Dominion University, Norfolk, VA. 23508.

The report of the synthesis of naloxazone, as a potent opiate antagonist, has promoted us to pursue the design of a potential phenylcyclidine (PCP) antagonist. In view of the structural similarity of ketamine (1) and PCP (2) we have attempted to prepare the corresponding hydrazone (3) and phenylhydrazone (4) analogs. While the hydrazone could not be prepared a possible phenylhydrazone product was obtained and evaluated against PCP effects. Both naloxazone and this new phenylhydrazone appear to inhibit PCP activity in mice.



STRUCTURE-ACTIVITY STUDIES OF THE 4, 4'-DIPYRIDYL-4, 5, 6, 7-TETRAHYDROIMIDAZO (4, 5-C) PYRIDINE RING SYSTEM. R. L. Williams and Sandra Neergaard, Dept. of Chemical Sciences, Old Dominion University, Norfolk, VA 23508.

4, 4'-Dipyrindyl-4, 5, 6, 7-tetrahydroimidazo (4, 5-C) pyridine (1) was prepared recently as part of our research program related to the novel condensation of histamine with various carbonyl compounds. During a routine behavioral evaluation (2) was found to exhibit a high degree of convulsant activity. In an effort to study the possible mechanism of action of this agent we have prepared a series of structural analogs (2-5) which we have now evaluated. This paper will discuss the synthesis, evaluation and SAR inherent in the possible mode of action of (2) as a convulsant.



ELECTRONIC STRUCTURES ON A GRAPHICS TERMINAL. John H. Wise, Dept. of Chemistry, Washington and Lee Univ., Lexington, VA. 24450.

Three programs in the CONDUIT package on quantum chemistry have been revised and extended for execution on the Tektronix 4025 graphics terminal connected to the Washington and Lee computer center. The host computer is the Harris 3125 employing the Tektronix PLOT 10 software. The programs modified are BOX, CONTOUR, and RADIAL.

BOXER extends the calculations of the energy levels for a particle in a one-dimensional box to include a plot of the wave functions for both the finite well and the infinite well cases.

HYBRID is a revision of CONTOUR to plot the size and shape of the $n = 2$ orbitals and their hybrid combinations, and DENSITY is a separate revision to plot a dot pattern diagram of electron density for an orbital in the $n = 1$ to $n = 3$ shell.

RADIUS presents a plot of the radial density functions of all atomic orbitals from 1s through 4p for a given atomic number followed by a plot of the Hartree-Fock radial distribution for the particular atom.

Examples of the output will be displayed and the applicability of the programs will be discussed.

CHARACTERIZATION OF INTRACELLULAR PEPTIDASE ACTIVITY IN EHRLICH ASCITES TUMOR CELLS. L. Wolfmberger, Jr., Dept. Biol. Sci., Old Dominion Univ., Norfolk, Va. 23508

Characterization of transport activity for small peptides in Ehrlich ascites tumor cells requires the simultaneous analysis of intracellular peptidase activity. Emphasis is placed on efforts to elucidated one or more peptides which are transportable by membrane localized transport systems but which are not hydrolyzable by intracellular peptidases.

Information to date suggests that the combined intracellular peptidase activity is capable of hydrolyzing peptides of differing sequences as well as chain length. Peptides in which glycine is the N-terminal residue are not good substrates and the presence of a D-stereoisomer as the second residue, adjacent to glycine, renders a peptide virtually immune to hydrolysis. (Aided in part by a grant from the ODU Research Foundation.)

AUTOMATED DIFFERENTIAL KINETIC ASSAY FOR HUMAN SERUM CREATINE KINASE-MB ISOZYME, J. H. Yuan and L. W. J. Pan, Dept. Of Chem. Sci., Old Dominion Univ., Norfolk, Va. 23508

It is well established that creatine kinase-MB isozyme (CK-MB) in normal serum is low and scarcely detectable. But following a myocardial infarction, CK-MB activity in serum begins to rise to reach a maximum within 24 hours, and then rapidly returns to normal. The determination of CK-MB has been demonstrated to be specific for the diagnosis of acute myocardial infarction. Different analytical techniques have been developed for quantitation of CK-MB such as column chromatography, electrophoresis, and immunological method. But all these methods are time-consuming, complicated, and skillful technicians are required. We have developed an automated method by using ABA-100 Abbott Biochromatic Analyzer for differential kinetic determination of serum CK-MB isozyme. The method is based on the fact that isozymes often exhibit different catalytic activity and kinetic behaviors with various substrates. The details of the method will be presented.

Education

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

CHANGES IN BALANCE AND HAND-EYE COORDINATION OF EDUCABLE MENTALLY RETARDED ADULTS AFTER AN EIGHT-WEEK SWIMMING PROGRAM C. H. Bell*, Jr., K. P. Bovard, R. K. Stratton*. Depts. of HPER and Animal Science, Va. Tech, Blacksburg, Va. 24061

In March, 1980, 38 adolescent educable mentally retarded (EMR) clients, aged 13-46 years were enrolled in an eight-week therapeutic recreation program. The swimming was supervised by college-aged instructors. Clients were from special education classes from the public schools or the sheltered workshop serving three counties. Data were obtained from 10 clients (5 male, 5 female) on two physical performance tasks, the stabilometer and the Shape-O-Ball, both at the outset and at the conclusion of the eight-week program.

Least squares analyses examined sex, trials (pre and post test), sex*trial interaction and client within sex. For contacts (number of times the balance bar touched the ground in twenty seconds), the overall mean was 19.2, $R^2=.69$, $SE \pm 3.78$ and sex was statistically significant ($P<.03$); for balance (time client was in balance during 20 sec. trial) the mean was 7.85, $R^2=.77$, $SE \pm .92$ and differences among clients, within sex were significant ($P<.04$); and, for the Shape-O-Ball (time required to put puzzle together) the mean was 67.0, $R^2=.90$, $SE \pm 17.1$ with these effects significant: sex ($P<.01$) with females 71.0 and males 63.0; trials ($P<.01$) with Trial 1 at 78.8 and Trial 2 at 55.2 and clients within sex ($P<.01$).

The program has been continued and, modified in part to reflect the finding from this study.

TEACHING BIOLOGY TO NON-SCIENCE MAJORS: THE OLD DOMINION PLAN. J. E. Browne and K. N. Nesius*, Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23508

Biology for non-science majors utilizes a modified version of the audio-tutorial methodology of Postlethwait. Various information delivery systems are used to attend to diverse backgrounds and differing cognitive styles. Computer managed diagnostic testing is utilized, with multiple testing opportunities. Comparisons are made between percentages of students at each mastery level for the present program and the traditional program. The average number of pre- and post-tests taken at each mastery level is analyzed and discussed.

EFFECTS OF CLASSROOM ANIMALS ON VERBALIZATION. B. B. Goldstein*. Dept. of Educ., W'm & Mary, Williamsburg, Va. 23185

The effects of classroom pets on verbalization were studied in a Title I setting in which the children were characterized as almost non-verbal. A series of six creative stories by each child in the control and experimental groups were examined and compared quantitatively and qualitatively. The children in the experimental group were taught reading and language skills using classroom pets as a springboard and medium for learning. The children in the control group were not allowed to interact or converse about the animals in class.

The data showed some qualitative changes in the nature of the stories, but these changes cannot be attributed to the use or non-use of animals due to the extremely small number of changes observed. However, there was a definite positive relationship between the use of classroom animals and the length of story (.01 level of confidence) and the number of descriptors used (.05 level of confidence). The data collected supported the hypothesis that the use of animals in the classroom would cause increased quantity and quality of verbalizations when judged by the length of story and the number of descriptors. There were several interesting behavioral reactions displayed by individuals involved in the study. These reactions, although discussed only briefly in the study, lend further support to the value of classroom pets and continued study of this topic.

MICROCOMPUTERS IN INSTRUCTION: A STATUS REPORT. R.L. Gull*, Supervisor, Courseware Development, Norfolk Public Schools, Norfolk, VA 23510

The microcomputer's processing power, memory capabilities, sound, color and graphics make it an extraordinary instructional tool. While the technology is capable, significant hurdles must be overcome before microcomputers will be accepted as an effective instructional supplement.

Two major problems exist, and corresponding suggestions are as follows:

- Lack of computer literacy skills by teaching personnel
 - . develop a long range computer literacy inservice plan
 - . bring in guest speakers with specialized skills
 - . conduct guided equipment hands-on activities
 - . allow for non guided equipment hands-on activities
 - . make equipment available in laboratory sites, or on a sign out basis
- visit existing microcomputer programs
- Lack of validated courseware (curriculum) for microcomputers
 - . establish a process for formally evaluating courseware
 - . request validation and/or field testing results
 - . require a demonstration of courseware on the school's equipment
 - . purchase courseware from an established reliable company.

SCIENCE TEACHERS PERCEPTIONS REGARDING POSSIBLE TASKS FOR PARAPROFESSIONALS IN SCIENCE EDUCATION. Alan Mandell. Department of Curriculum and Instruction, Old Dominion University, Norfolk, Va. 23705.

A questionnaire listing 26 possible tasks for paraprofessionals in secondary/middle school science teaching was administered to a sample of 32 science teachers to obtain their perceptions of appropriate tasks for such personnel.

The respondents were asked to check one of four columns labeled "Very Appropriate", "Possibly Appropriate", "Not Too Appropriate", and "Definitely Not Appropriate" for each task. The four columns were weighted and the mean rating and standard deviation for each task was computed. The list of tasks was then ranked on the basis of the mean ratings.

There was strong agreement in this sample that the 'professional' aspects of teaching such as lecturing, demonstrating, disciplining, and taking responsibilities were not appropriate for paraprofessionals. The more mundane tasks of assisting in laboratory activities, grading papers, operating audio-visual equipment, and maintaining bulletin boards were deemed appropriate.

Ninety-seven percent of the sample felt that a paraprofessional would be of assistance to their science department. Seventy-eight percent would like to have personal paraprofessional assistance.

A COURSE FOR SENIOR HIGH GIFTED STUDENTS: THE BAY, EXPLORE IT: AN ECOLOGICAL STUDY OF THE CHESAPEAKE BAY. L. W. McLAMB*, Old Donation Center for the Gifted and Talented, 1008 Perry Plantation Rd., Va. Beach, VA 23455

A course for secondary gifted students focusing on the ecology of the Chesapeake Bay was developed at the Center for the Gifted during the Spring of 1980. Sixty-five students, from grades seven through twelve were involved in thirty-five hours of instruction. A variety of instructional strategies including Parnes' Creative Problem Solving Process, Tabas' Inductive Teaching Model, and Schwab's Biological Science Inquiry Method were integrated into an activity-oriented instructional unit emphasizing student involvement in field investigations.

Formative and summative evaluation instruments were developed to assist in determining changes in student knowledge, effectiveness of instructional activities, and the effectiveness of the course in meeting stated objectives. Following analysis of the evaluation information, revisions were made and the course was offered during the Spring of 1981. In the Spring of 1982 the course will be included in the Virginia Beach City Public Schools curriculum as an elective credit offering for senior high gifted students.

Funding Assistance provided by the Citizens' Program for the Chesapeake Bay, Inc.

MULTIPLE OPTIONS GRADING SYSTEM: CORE MATERIAL MASTERY INSTRUCTION AND PERSONALIZED EDUCATIONAL ARENAS.

James F. O'Brien, Tidewater Community College, Virginia Beach, Virginia 23456.

If colleges and universities are to reify their goal of producing people who can think more clearly, more critically and more comprehensively; then professors must know how and when to practice the classical distinction between educator and instructor. The following model is explored: (1) identify the core material and require its mastery to count about one-third of the highest grade in the course; (2) set priorities on the remaining material, weigh these topics differentially, and let the student select among them, (3) consider the tools that are used in fields relevant to course material, and create and weigh opportunities that will encourage student practice with these tools; and (4) set deadlines, give clear instructions, and negotiate emergencies. Advantages: (1) competence rather than competition is graded; (2) more students earn higher grades; (3) the teacher effectively weds education and instruction; (4) the student is more likely to become self-educating; (5) teaching assistants are more likely to develop broader knowledge and skills. Disadvantages: (1) a slightly higher withdrawal rate; (2) more time required for grading; (3) more time required for initial preparation of materials and training of assistants; (4) extra anticipation of students' needs and anxieties requiring clarity and consideration. Examples of effects and course materials are presented.

EXPLORING BIOLOGICAL SCIENCES CURRICULUM STUDY AND NUFFIELD BIOLOGY. A.L. Mannarino, Dept. of Science, Smithfield High School, Smithfield, VA 23430

This study explores the similarities and differences in both BSCS and Nuffield Biology methods of teaching science through inquiry. Although BSCS and Nuffield Biology are similar in goals, they are vastly different in the approaches they take. For instance, BSCS combines the theory of biology with its practical application. It is the textbook rather than the teacher which dictates the structure of the curriculum. On the other hand, the Nuffield Biology method of inquiry utilizes the teacher as both the source of the theoretical information and the coordinator of the laboratory activities, whereas BSCS is somewhat rigid in structure.

Nuffield is flexible enough to meet the teacher's objectives. BSCS provides an innovative approach with definite advantages over the previous texts and methods used in the United States. Nuffield Biology, the British counterpart, emphasizes the inquiry approach to a greater degree, pushing the student towards greater exposure to the scientific method of thought. Nuffield Biology achieves its goals through a five year sequential and developmental program of study, beginning at age eleven and carries it through to the age of sixteen. If the BSCS approach were to be extended beyond the confines of a single year of study, its goal as a method of scientific inquiry could be comparable to the Nuffield Biology concept.

CURRENT TRENDS IN ENVIRONMENTAL EDUCATION. Teresa Myer, Science Service, Va. Dept. of Education, Richmond, Va. 23216

The basic aim of environmental education is to help individuals understand the complex nature of the natural and built environments; and to acquire the knowledge, attitudes, and skills to participate in a responsible and effective way in integrated environmental management.

There have been both problems and progress in achieving this goal. The difficulty in defining environmental education and its interdisciplinary nature has resulted in a lack of academic respectability and has presented a problem in finding space for it in the traditional curriculum. A great deal of time and effort has been spent in seeking leadership and funding from the federal government, but strong support was never forthcoming. Successes have more often been the result of grassroots movements of individuals and coalitions of agencies and organizations.

Virginia has several successful environmental education programs in local school divisions and has an association which assists in statewide communication. The Science Service of the Va. Dept. of Education is taking steps to help infuse environmental education into the science curriculum. Both in-service and pre-service teacher education continues. Inclusion of environmental/energy concepts is one criteria by which science textbooks are evaluated. Finally, several learner outcomes in the K-12 Standards of Learning Program for science deal with environmental education concepts.

THE SPIDER MUSEUM. LaVonne B. Schurman*, Coordinator, Mathematics and Science Center, Richmond, Va. 23223

The Spider Museum, with its collection of objects and living arachnids from around the world, is dedicated to educating people about spiders and dispelling fears of people that most spiders are evil and harmful.

Visitors are made aware of: the usefulness of spiders in the environment; how man benefits from spiders; the lack of scientific knowledge of the arachnids; and the folk-lore and superstitions still surrounding the arachnids.

Students are encouraged to develop scientific investigations and activities relating to spiders, and are made aware of the many species of spiders. Spiders are found in all parts of the world and many species have never been classified, or so it is believed.

The daily logs and/or data on each of the twenty(20) or more live specimens can be used in the publication of articles dealing with the behavior and life patterns of different species.

THE USE OF RESEARCH REACTORS FOR EDUCATIONAL PROGRAMS IN SCIENCE. B. L. Shriver and P. E. Benneche*, Dept. of Nucl. Engr. & Engr. Physics, Univ. of Va., Charlottesville, VA. 22901.

The University of Virginia Reactor Facility is widely used to support educational programs in science at other universities and colleges in Virginia. This work is supported by the U. S. Department of Energy under the Reactor Sharing Program.

The University of Virginia Reactor Sharing Program consists of two parts. First, students from area colleges visit the Reactor Facility to perform experiments in radiation, radioactive decay, radioisotope applications in science and industry, and reactor experiments. Over 200 students from ten Virginia universities and colleges have participated in this program.

Secondly, the reactor and counting facilities are used to support research, primarily in the use of neutron activation analysis for analysis of environmental and biological samples. The majority of the research conducted under this program has been conducted by faculty and students from James Madison University departments of Biology and Physics. These projects have used neutron activation analysis to determine the composition of airborne particulates, measure long term uptake of pollutants by trees and the effects of cadmium in rats.

MARINE SCIENCE AT OLD DOMINION UNIVERSITY, AN OPPORTUNITY FOR SECONDARY SCHOOL GRADUATES. H. B. Stewart, Jr. Ctr. for Marine Studies, Old Dominion University, Norfolk, Va. 23508

Educational programs in marine science have taken on increased importance in Virginia universities as the public becomes more aware of and concerned about our abundant marine resources. Critical to the effective management of these resources is a better understanding of the resources themselves and of the complex estuarine and nearshore oceanic environments in which they are found.

Old Dominion University with its expanding program in marine science education and research provides an opportunity for the serious secondary school senior with a marine science career in mind. For the university graduate, the freshman with oceanographic interests is encouraged to investigate the various physical and life science that constitute the science of oceanography: physics, biology, chemistry, and geology with a view towards majoring in one of these basic science fields. An undergraduate course in general oceanography is available, and a newly instituted program of a minor in marine science is available to the student majoring in one of the basic sciences.

A graduate program leading to the MS and PhD degrees in oceanography is conducted by the Department of Oceanography with concentrations in the fields of biological, chemical, geological, and physical oceanography. In the 1980-81 school year, there were 109 graduate students enrolled in the Department of Oceanography. Counselors are encouraged to contact ODU

Engineering

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

SEASONAL COLLECTION AND STORAGE OF SOLAR ENERGY BY COVERED POOLS. J. T. Beard, L. U. Lilleleht, and F. A. Tachetta, School of Engineering and Applied Sciences, Univ. of Va., Charlottesville, VA 22901

The concept of seasonal collection of solar energy and storage in a covered pool of water has been analyzed with the aid of a digital computer simulation program. Parts of the model were validated by successfully simulating the thermal performance of a prototype collection/storage system sized for a single-family residence in central Virginia. The experimental system consisted of a 104 m³ pool covered with 53.5 m² nearly horizontal trickle-type collectors.

As the prototype system turned out to be inadequate for the intended service, a number of design modifications were investigated through computer simulation. These included increased energy collection, reduced heat losses, and the use of a water-source heat pump rather than direct heating with the pool water.

The results show that the fraction of the heat load for a single-family residence deliverable by the seasonal collection/storage system increases significantly with the various design modifications and can be made to approach unity.

Life cycle costs are presented for the prototype pool system along with comparisons with those for the various design modifications in terms of annualized costs.

INVESTIGATION OF A SPECIAL PASSIVE THERMAL SIPHON CONCEPT FOR THE REDUCTION OF COOLING LOADS. J. W. Dille*, Brown Shoe Company, St. Louis, MO 63131, and J. T. Beard, Dept of Mechanical and Aerospace Engineering, University of Va., Charlottesville, VA 22901

The University of Va. and the U. S. Dept. of Agriculture Stored Tobacco Insects Lab. have been engaged in research to develop a cooling system for controlling insect growth in stored tobacco. In an effort to reduce cooling loads, a solar driven thermal siphon has been evaluated through the use of a computer program which simulates the flow between the two parallel vertical walls. The outside wall is exposed to the sun, and the inner wall is an insulated surface. The air channel between the two walls is vented at the top and bottom, allowing ambient air to flow through and thereby remove a large portion of the solar gain of the building.

The analytical problem involves fluid dynamics, both forced and free convection heat transfer, buoyant driving forces, and radiation and conduction heat transfer.

This paper describes the results of the simulation with recommendations for the channel width and insulation thickness on the inside wall and with indications of the expected reduction which would occur in building cooling loads.

DESIGN OF CAPSULES FOR IRRADIATION OF REACTOR PRESSURE VESSEL STEELS IN THE UNIVERSITY OF VIRGINIA REACTOR. C. A. Bly*, J. L. Kelly* and B. L. Shriver. Dept. of Nucl. Engr. & Engr. Phys., Univ. of Va., Charlottesville, VA 22901.

An irradiation capsule has been designed that allows precise determination and control of the radiation flux and specimen temperature during irradiation. The volume of the specimen region of the capsule is about 60 cm³. The use of well-machined metal surfaces, radiation-tolerant sealants, and screw fastenings in the construction of the capsule has ensured that it is reusable. Capsule cooling is achieved by diverting 1.0% of the primary coolant flow of the Univ. of Va. Nuclear Reactor through the flow-channel containing the experiment. Boral is included in the capsule structure to reduce thermal neutron activation of the material specimens.

Design calculations involved coupled analyses of radiation attenuation and its attendant heating, additional heating supplied by resistance heaters, and heat transfer and fluid flow which apply to the capsule geometry.

A dummy capsule was designed, fabricated, and tested to assure that all design criteria were satisfied. This capsule program met the design objectives, and presently we are involved with the fabrication and testing of the first generation of test capsules.

The test capsule design can serve as a prototype design of single fuel-element sized irradiation capsules that can be used at all nuclear research facilities during standard M.T.R. type fuel elements.

AN ANALYTICAL MODEL OF THE ICE ACCRETION PROCESS. R.D. Kirchner. Institute for Hypersonic Studies, Inc., 7602 Cornwall Road, Richmond, VA 23229.-Currently on active duty in the U.S. Air Force.

Today many civilian and military aircraft lack the necessary de-icing or anti-icing capabilities to allow safe/successful operation during icing conditions. The present investigation attempted to establish a time dependent numerical solution of the ice accretion process that could predict the extent of icing under all icing conditions. A computer simulation of the icing process was developed for test cases involving a 2.54 cm in diameter circular cylinder with both rime and glaze icing conditions. A Lagrangian approach was used to establish impact locations for individual water droplets; and the equilibrium heat transfer condition was established along the surface to determine the extent of icing. Variations and effects of surface roughness were incorporated into the convective and evaporative heat transfer relationships, and the ice density was allowed to vary as a function of the droplet impact velocity and the surface temperature. Predictions of the icing patterns were found to be in favorable agreement with experimental results when using a heat transfer relationship that was extrapolated from experimental heat transfer data on a roughened cylinder.

SENSOR-ERROR RELATIONSHIPS FOR MACHINE VISION MENSURATION. E. S. McVey*. Dept. of Electrical Engineering, Univ. of Va. 22901

Machine vision is becoming an important technology for advanced automation and instrumentation. It can provide a visual input to many kinds of systems for applications such as material handling, medical analysis and robotics. The ability to make distance and dimension measurements will expand even further the potential of machine vision. To make measurements, it is necessary to establish relationships between object space and the vision sensor geometry. This can be accomplished in terms of sensor array size and measurement accuracy.

THE IMPACT OF TREATED SEWAGE EFFLUENT AND STORMWATER RUNOFF ON THE ALGAL GROWTH POTENTIAL OF THE OCCOQUAN RESERVOIR. K. G. Saunders* and T. J. Grizzard*. Occoquan Watershed Monitoring Lab., Va. Polytechnic Inst., Manassas, Va. 22110

During the period July 1978-December 1979, algal growth potential studies were conducted on Occoquan Reservoir waters using a modified bottle test. Productivity in the reservoir varied from low to high (0.0-29.3 mg/l dry weight) during the study period. Ortho-phosphorus concentrations varied concurrently (0.00-0.12 mg/l). Over 90% of the samples were phosphorus limited. Phosphorus enters the reservoir system in treated sewage effluent and stormwater runoff. Productivity was consistently high during and following periods of storm runoff. Superior phosphorus control in the new advanced wastewater treatment plant limited the algal growth potential of the reservoir during low flow periods.

BENEFITS OF HAVING UNDERGRADUATE STUDENTS PARTICIPATE IN THE OPERATION OF ENGINEERING RESEARCH FACILITIES. Bryce L. Shriver Dept. of Nucl. Engr. & Engr. Phys., Univ. of Va., Charlottesville, Va. 22901

The need for including practical experience in undergraduate engineering programs has long been known. One method for achieving this is by having students work in research facilities operated by engineering schools, such as research reactors.

One specific case, the training of undergraduate students to operate the Univ. of Va. Research Reactor, has been reviewed. Since 1979 over 40 students have been licensed by the Nucl. Reg. Comm. to operate the Univ. of Va. Reactor.

A survey of nuclear engineering students was performed to provide information concerning the benefits of the training program. Both reactor operators and non operators considered that the training program was beneficial in each of the ten areas surveyed. As expected the educational areas most enhanced were those emphasized by the training program and subsequent work experience, such as reactor operation, reactor systems, and nuclear instrumentation.

In addition it appears that the availability of this training program is a significant factor in the student's decision to major in nuclear engineering. In addition the graduate enrollment is significantly higher than that of non-operators as shown by the fraction of reactor operators who enroll in graduate school (54%) as compared to that for non-operators (31%).

IODINE PARTITION COEFFICIENT AT LOW CONCENTRATIONS IN PURE WATER. R. U. Mulder*, C. J. Baba*, and J. L. Kelly* Dept. of Nucl. Engr. & Engr. Physics, Univ. of Va., Charlottesville, Va. 22901

The study of iodine chemistry and iodine partition coefficients at low aqueous concentrations was begun some twenty years ago. As part of that effort, a theoretical model predicting iodine partition coefficients was developed by A.E. J. Eggleton. Other workers provided some experimental checks at scattered values of pH, temperature, and iodine concentration. These early results indicated that Eggleton's model represented a conservative estimate of iodine partition coefficient values (i.e., predicted values lower than actual values). Since the Three Mile Island incident, there has been a renewed interest in realistic evaluations of the radiiodine source terms. In light of this interest, our work was undertaken to evaluate the iodine partition coefficient over the following range of conditions in pure water: T=30, 50, 70°C; pH = 5, 7, 9; iodine aqueous-phase concentrations = 10^{-4} to 10^{-10} g/cc.

Our experimental results conform to Eggleton's model for aqueous iodine concentrations in excess of about 10^{-6} g/cc. However, for all conditions examined, the experimental partition coefficient approaches a fairly constant value of 1000 at very low concentrations. This is in sharp contrast with Eggleton's theory, and is explainable in terms of HIO volatility. Also, the value of the partition coefficient is quite sensitive to the presence of impurities.

HYBRID THERMOELECTRIC SOLAR COLLECTOR DESIGN AND ANALYSIS. K. Shaheen* and A. S. Roberts, Jr.* Dept. of Mechanical Engr. and Mechanics, Old Dominion Univ., Norfolk, Va. 23508

A flat-plate solar collector is conceived which would provide DC electric power while energy is transferred from the absorber plate to the heat transfer fluid. The work reported here represents a preliminary design study which involved the steady-state modelling of the collector and a parametric study of thermodynamic performance. Thermoelectric modules are imbedded in the absorber surface over a parallel array of vertical tubes connected by inlet and exit headers; energy cascades through the modules before being convected away. Electric power produced can be utilized to drive pumps, fans and controllers. The results of this parametric study, if favorable, will be used for experiment design and preliminary economic analysis of "stand-alone" solar collector arrays. (Partial support by NASA Langley Res. Ctr.).

OPTIMIZATION OF A SOLAR SOURCE HEAT PUMP FOR RESIDENTIAL SPACE HEATING. J. J. Tandler* and M. R. Sexton, School of Engineering and Applied Science, University of Virginia, Charlottesville, Va. 22901

A solar source heat pump heating system design was optimized to provide lowest annual cost. A liquid collector, water tank storage system was simulated using the TRNSYS computer program. Thermal performance results from the TRNSYS program were used in a second computer program to optimize the system for lowest annual cost. Heat pumps designed for the higher evaporator temperatures resulting from solar source applications were considered. Results showed that high collector efficiency does not necessarily mean better system performance, and that annual cost was not a strong function of storage volume.

NASA/HAMPTON REFUSE FIRED STEAM PLANT: A SMALL SCALE FACILITY WITH LARGE SCALE TECHNOLOGY. Hunter F. Taylor, PE
Charles R. Velzy Associates, Inc., Richmond, Virginia

The most recent solid waste processing facility in the U.S. started up in Hampton, Virginia in September, 1980. The plant utilizes "mass-firing" to burn 200 tons/day of unprepared municipal solid waste from the City of Hampton and supply steam at 360 psig. to NASA-Langley Research Center. The process comprises two 100 TPD waterwall furnaces with integral boilers, reciprocating grate stokers, electrostatic precipitators, and state-of-the-art analog controls for automatic operation of the boilers. The \$10.4 million facility is of particular interest for several reasons:

1. It is a joint venture between a federal agency seeking to decrease its consumption of fuel oil and a coastal city seeking an alternative to landfill disposal.
2. The process design emphasizes steam plant technology for solid fuels rather than disposal technology for solid wastes.
3. It uses limited source separation to minimize fueling handling costs and outages due to bulky items while eliminating the need for shredding.
4. It is intended to demonstrate the feasibility of utilizing waterwall furnace/integral boiler technology for MSW throughput of only 100 TPD. (It is the smallest plant of this type).

Environmental Science

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

OPEN OCEAN DISPOSAL OF DREDGED MATERIALS: A BIOLOGICAL ASSESSMENT OF SPOILS FROM THE PORT OF HAMPTON ROADS. R. W. Alden. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

A study was conducted to determine the potential biological impact of open ocean disposal of spoils dredged from the Port of Hampton Roads, Virginia, a highly industrialized seaport system. Spoil fractions of sediments from a number of potential dredge sites were tested through a series of lethal and sublethal bioassay experiments with the grass shrimp *Palaemonetes pugio*. Dissolved and suspended materials which would be released during disposal operations did not produce significant lethal effects for most of the sites tested. However, rapid lethal effects were observed during the suspended solid phase experiments for a few of the most highly industrialized sites. Significant depression in respiration rates was noted for shrimp surviving exposure to elutriates of sediments from these sites. Exposure of the shrimp to the heaviest fraction of the spoils produced moderately low mortalities throughout all ten day experiments. Iron, manganese and zinc were the only metals to accumulate significantly in the shrimp during these experiments.

These preliminary findings indicate that much of the sediments from Hampton Roads is of adequate quality for open ocean disposal, although current and pending investigations have been designed to examine various aspects of this topic in greater detail.

HYDRAULIC MODEL INVESTIGATION OF POLLUTANT SPREADING AROUND MARINAS. Carvel Blair, Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508

A properly adjusted Froude model reproduces accurately some of the physical phenomena in an estuary. Other phenomena are distorted. In the case of mixing of dissolved pollutants, existence of similitude depends upon which phenomena, if any, dominate the mass transfer process. Assisted by a Sea Grant, ODU is investigating how to use the Corps of Engineers' Chesapeake Bay Model to predict the temporal and spatial spread of pollutants in the vicinity of marinas. In those locations in which similitude exists, model data can help establish shellfish barrier zones in the prototype.

Prototype dye tracer experiments have been conducted in the Lafayette River and (through a cooperative investigation at the Virginia Institute of Marine Science) in Green Mansion Cove off Mobjack Bay. Preliminary model tests verified the prototype Lafayette River data. Work has been delayed by damage to the model, but will resume in summer 1981. The effect of freshwater discharge will receive special attention.

AMBIENT AMMONIA MEASUREMENTS USING LASER PHOTO-ACOUSTIC SPECTROSCOPY. M.D. Aldridge III*, G. E. Copeland, C.N. Harward. Department of Physics, Old Dominion University, Norfolk, VA , 23508.

Measurements of gaseous atmospheric ammonia from September 1980 to mid-March 1981 were obtained with an experimental system employing laser photo-acoustic spectroscopic techniques. Ammonia concentrations reached minimal levels (approximately 0.1 ppb) in early winter, followed by a sudden late winter increase. A direct relationship between ambient ammonia levels and air temperature was inferred from the data (linear correlation coefficient $r = 0.53$). Ammonia concentrations were determined to be directly related to the absolute humidity of the air ($r = 0.72$); a weaker relationship between ammonia concentrations and relative humidity was discovered ($r = 0.37$). The data also indicated that ammonia levels were generally higher within continental air masses than those of maritime origin. Soil parameters such as pH and moisture content were found to have a major bearing on the release of gaseous ammonia from soils in the region.

MODELING OF TRACE METALS IN THE ATMOSPHERE. L. L. Brooks*. Dept. of Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508

The behavior of trace metals in the atmosphere is a relatively unknown science. Sources of the metals come from both natural and anthropogenic categories. The use of coal, an important source of trace metals will rise substantially as the United States strives to become energy self sufficient. The combustion process of coal will enrich certain metals in the flue gases. Particle size seems to be one of the most important parameters and trace metals appear to be divided into three size groups - 0.54, 4.0, and 11.0 micrometers. The particles follow the normal log distribution. The removal of metal particles is done by two processes, wet and dry deposition. Analysis of these particles can probably best be accomplished by neutron activation, but the most cost efficient analysis would be atomic absorption spectrophotometry. Analysis of particles has shown a wide variability of individual metal concentration without regard to total mass collected. Modeling of metals in the atmosphere using principal components analysis has great promise since the model would enable geographic regions to be identified not only by amounts of particles but also by the metal concentrations in the particles.

COPROSTANOL AS A POTENTIAL TRACER OF PARTICULATE SEIAGE EFFLUENTS. R.C. Brown and T.L. Wade, Dept. of Oceanography, Old Dominion University, Norfolk, Va. 23508

A total of 66 samples, collected in the Chesapeake Bay entrance and adjacent shelf waters, were analyzed for particulate coprostanol concentration. Coprostanol, an indicator of fecal contamination, may originate in these waters from the discharge of sewage treatment plant effluent, land run off, or direct discharge from ships in the area. Surface coprostanol concentrations were fairly uniform, with a slight increase with depth. This increase with depth may be due to sewage associated particulates settling as they leave the bay, or the resuspension of contaminated sediment. Preliminary indications are that sewage associated materials are being transported from the Chesapeake Bay to shelf waters, where they may have a detrimental affect on living marine resources.

CHARACTERISTICS OF THE TURBID QUALITY OF WATER AT THE ENTRANCE TO CHESAPEAKE BAY AND IN NEARSHORE WATERS OF THE CENTRAL VIRGINIA EMBAYMENT. M.R. BYRNES*, K.J. Gingerich*, and G.F. Certeil. Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508.

The characteristics and distribution of total suspended particulates at the mouth of Chesapeake Bay and in coastal waters off Virginia Beach illustrated three apparent source areas. Suspended material assemblages were associated with: 1) runoff, 2) resuspension of material within the Bay, and/or 3) resuspension of material over shoals and in regions adjacent to the coast. Since "near drought" conditions existed for several months prior to the survey, resuspension due to wave and current action was a major source of turbidity.

Cross-sectional plots of total suspended matter illustrated the three areas characterized by different resuspension processes. Regions adjacent to the coast of Virginia Beach showed two distinct areas characterized by turbid water; a surface "turbid plume" associated with resuspension and dispersion of material by currents and a near-bottom "turbid layer" associated with resuspension by waves and minimal dispersion by currents. The outwelling of Chesapeake Bay water was also characterized by high turbidity. This was associated with suspension of particles over shoals in the northern Bay mouth and subsequent transport of material in a southeasterly direction.

SCALE EFFECTS OF HYDRAULIC MODELLING OF BUOYANT FREE SURFACE THERMAL PLUMES. Li-Cheng Chu*, and John M. Kuhlman, ODU, Norfolk, VA 23508

Small scale hydraulic modeling of a buoyant thermal plume in a crossflow is essential to the accurate prediction of mean thermal plume size and trajectory, since field studies are usually too costly and uncontrollable, and since the theoretical models are somewhat unreliable as predictive tools. In the present work, a 5 m square hydraulic flume has been utilized to obtain mean plume size and trajectory data, using thermocouples and dye injection, for a range of jet-to-crossflow velocity ratios, Reynolds numbers, and a range of jet internal Froude numbers (ie, various jet-to-crossflow temperature differences).

Computer generated three-D mean plume isotherm contours indicate the existence of a weak vortex structure in the upstream side of the plume. Dye and thermal measurements of mean plume width and trajectory indicate a large effect of Reynolds number on mean plume characteristics, while turbulence generating grids placed in the crossflow or jet channels have little effect on the plume. Thus, scale effects due to lack of dynamic similarity (model Reynolds number too small) appear to be too large to allow using laboratory thermal plume data directly on a predictive basis. However, lab data should be of great value in improving theoretical plume models. (Aided by NSF grant ENG-78-00815).

A PRELIMINARY STUDY ON THE INGESTION OF DETRITAL MATERIAL BY PALAEMONETES PUGIO, USING ^{14}C RADIOLABELING METHODS. M. P. Crosby*, L. Wolfenbarger, Jr., and R. W. Alden, III, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, VA. 23508

A new procedure for radiolabeling detrital particles is presented. The methodology involves methylation of detrital material (90-125 μ) with ^{14}C dimethyl-sulfate in an alkaline media and requires less than two hours to perform. The formed covalent bond is stable over time at 0°C and to acid hydrolysis.

A preliminary feeding study was conducted to determine if *P. pugio* is able to utilize the labelled detrital material. Serial sampling of *P. pugio* was conducted during a 24 hour feeding. Results of the whole body liquid scintillation (LS) counting assay indicated differences in uptake of the detritus by different size ranges of shrimp and a general increase in CPM's in the shrimp over the duration of the study. Implications of these results on future studies are discussed.

VARIABILITY IN THE TURBID QUALITY CHARACTERISTICS OF WATER IN THE CHESAPEAKE BAY ENTRANCE AND RELATIONSHIPS WITH WATER MASS BOUNDARY CONDITIONS. K.J. Gingerich*, M.R. Byrnes*, and G.F. Certeil. Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508.

In the mouth of Chesapeake Bay, water mass boundary conditions illustrated a variety of characteristics. Two types of estuarine fronts were observed in the entrance to Chesapeake Bay. The first type of frontal feature was apparently controlled by tidal currents and bathymetry. Strong turbidity gradients across these fronts were primarily affected by variations in total suspended matter concentration. The average variation across the frontal boundary, based on the analyses of six fronts, was 13 mg/l. The magnitude of shear, surface convergence, and surface roughness was apparently related to relative speeds of tidal currents around shoals and channels. A second type of estuarine front was maintained by bathymetry, as well as pronounced salinity gradients (.02 to .08 o/oo per meter, horizontally).

High turbidity water was confined to shallow margins of fronts rather than in channels. In general, the outwelling of Bay water through numerous channels illustrated lower turbidity than shallow water over entrance shoals.

COHERENCE BETWEEN WIND AND CURRENT EVENTS IN A NEARSHORE, SHALLOW WATER, WAVE DOMINATED ENVIRONMENT. G.M. Hecker, Department of Oceanography, Old Dominion Univ., Norfolk, VA. 23508

Five days of observations were made of the current at 4 depths in a water depth of 8 m, and an accompanying record of local wind, 0.5 Km offshore at Duck, N. Carolina, beginning 5 May, 1978. The current was measured with an electromagnetic current meter having a 0.2-sec. response and ± 2 cm/sec accuracy. At each depth a 10-min. record was made each hour with a sampling interval of 1/8-th sec. The frequency components of the record were analyzed and found to be essentially free from noise and bias. The record of 120 ten-min. averages was also analyzed for components. Semidiurnal and diurnal components and quadratic curve trends were identified. Analysis by fast Fourier transform revealed that the component of the wind perpendicular to the coast had significant coherence with the alongshore component of the current.

AN ANALYSIS OF METHODOLOGIES FOR ESTABLISHING PRIORITIES FOR USE OF CHESAPEAKE BAY WATERS. Waldon R. Kerns. Water Resources Research Center, Va. Polytechnic Inst. and State University, Blacksburg, Va. 24061

One objective of the resource allocation process is to gain efficiency in use of scarce resources by allocating them to the highest valued use. This paper provides a brief state-of-the-art review and evaluation of approaches to place a value on the varied and conflicting uses of an area's water resources. Focus is placed on water quality as an example of the potential application of the relationships between water quality parameters and alternative uses of the waters as a means to establish use valuation as a guide to resource allocation decisions.

ALTERNATIVE STRATEGIES FOR IMPLEMENTATION OF AREAWIDE WATER QUALITY PROGRAMS. Waldon R. Kerns. Water Resources Research Center, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A critical issue facing resource managers and "decision makers" with respect to managing nonpoint pollution is whether the direct regulatory approach is an efficient and equitable means of achieving goals. Economists and others including the legal profession are now advocating consideration of institutional changes to the system of management. This paper evaluates the use of alternative strategies including but not limited to bargaining, threat of litigation, economic incentives, tax systems, system of marketable rights, and residual charges. A distinction is made between strategies for management of traditional types of pollutants and the control of highly dangerous substances where risks are difficult to gauge.

THE CHEMICAL COMPOSITION OF PRECIPITATION IN THE LOWER CHESAPEAKE BAY. J. I. Kiss* & G. T. F. Wong*. Dept. of Oceanography, Old Dominion Univ. Norfolk, Va. 23508

Samples of rainfall were collected from individual rain events over a six month period at four locations adjacent to the Chesapeake Bay (Norfolk, Gloucester Point, Kilmarnock and Cedar View), and analyzed for pH and nutrients. The values of pH ranged from 3.3 to 4.6. Lower values were observed at Norfolk and Gloucester Point. The concentration of reactive phosphate and total phosphorus varied from 2.6 and 2.2 μM respectively to undetectable. Organic phosphorus constituted a significant fraction of phosphorus in some instances. The concentration of nitrite ranged from 0.34 μM to undetectable and ammonia concentrations fluctuated between 89.7 and 4.5 μM .

A COMPARISON OF THE INITIAL DATA USED BY THE FLEET NUMERICAL OCEANOGRAPHIC CENTER AND THE NATIONAL WEATHER SERVICE UTILIZING A BAROTROPIC PRIMITIVE EQUATION (PE) MODEL. J. V. Koziana*, and J. D. Lambeth*. Old Dominion University, Norfolk, Va. 23508

Initial data is an important part in the accuracy of a forecast of a numerical model. A comparison is made of the initial data used by the Fleet Numerical Oceanographic Center (FNOC) and the National Weather Service (NWS). The major differences between the two data fields are the FNOC data incorporates satellite data over water in the determination of the pressure height field at 300 millibars and there are additional station observations over the ocean areas in the FNOC data. The pressure height field data used is over the Pacific Ocean and Western United States during May 1979 and is compared utilizing a barotropic primitive equation model. A comparison of the two forecasts to the actual occurrence is done by using a S2 skill score. A subjective comparison is also made by synopticians who evaluate the two forecasts. (Funded by NASA LARC grant NCCL-34)

FRACTIONATION OF DISSOLVED ORGANIC CARBON IN ESTUARINE WATER AND SEAWATER. T.W. Catts, Jr., G.T.F. Wong*. Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508

Dissolved organic matter (DOM) in estuarine water and seawater was fractionated by conventional filtration through a glass fiber filter and then by ultrafiltration. Fractions containing total DOM and DOM with nominal molecular weights of $<10^3$, $<10^4$, $<3 \times 10^4$ and $<10^5$ were obtained and the concentrations of dissolved organic carbon (DOC) were measured. Estuarine water had a higher concentration of total DOC and a higher percentage of the DOC was in the fractions with higher molecular weight. The majority of the DOC in seawater was found in the fraction with molecular weights below 10^3 .

REMOTELY SENSED WATER TURBIDITY CHARACTERISTICS OF THE NEAR-SHORE GEORGIA EMBAYMENT AND RELATIONSHIPS WITH ESTUARINE DYNAMICS. G.F. Oertel and G. August*. Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508

The areal extent of inlet associated turbid plumes and their relationship with tidal stage was determined using optical density measurements of bands 4 & 5 of LANDSAT images. The shapes of density anomalies associated with inlets changed with the tide. Anomalies imaged during low tide exhibited well-rounded boundaries, whereas those imaged during high tide were smaller and had crenated boundaries. The density anomalies associated with inlets were thought to be associated with turbid plumes from terrestrial runoff, however, a part of the turbidity was apparently associated with the resuspension of fine-grained particles from the seabed. High tide plumes had the same areal extent as the corresponding ebb deltas, never varying by more than an order of magnitude. Low tide plumes were much larger and varied from the sizes of the corresponding ebb delta to greater than twice the size of the ebb delta.

If the turbid anomalies were indicators of the distributions of the water that had drained tidal lagoons, then the turbid water of the drained lagoon was generally restricted to the upper 0.5 to 2.0 m of water. Field measurements of temperature, salinity, and suspended solids illustrated that the outflow from many of the inlets was homopycnal, and that a significant portion of the optical anomalies thought to be turbid outflow plumes were produced by the resuspension of fine-grained particles.

THE INFLUENCE OF FRONTAL MECHANICS ON THE VARIABILITY OF HYDROCARBON CONCENTRATIONS IN THE ENTRANCE TO THE CHESAPEAKE BAY, G.F. Oertel, D.J. Velinsky, and T.L. Wade, Dept. of Oceanography, Old Dominion University, Norfolk, VA.

Concentrations of hydrocarbons in the entrance to Chesapeake Bay illustrate significant temporal and spatial variabilities. In general, concentrations in the bay mouth ranged from 4-14 µg hydrocarbons per mg suspended matter, whereas seaward of the entrance concentrations ranged from 1-2 µg/mg. Concentrations were higher in areas of resuspension and at the boundary between "outwelling" bay water and shelf water. In the Chesapeake Bay entrance concentrations of particulate hydrocarbons were 2.5 to 3.0 times greater in the summer of 1980 than in winter of 1981. In January 1981 observations at water mass boundaries within the bay entrance illustrated significant enrichment in concentration of particulate hydrocarbons, at frontal interfaces.

A preliminary descriptive model of the Chesapeake Bay entrance illustrates that convergent frontal systems and areas susceptible to resuspension by waves and currents, can maintain relatively high concentrations of particulate hydrocarbons.

MONITORING RESPONSE TO A MAJOR KEROSENE SPILL IN THE OCCOQUAN WATERSHED. S. M. Oertel*, B. L. Wood and T. J. Grizzard*. Occoquan Lab., Va. Tech., Manassas, Va. 22110

During March, 1980, a 32-inch refined petroleum pipeline traversing the Occoquan Watershed burst. Within a short time, approximately 326,000 gallons of kerosene had spilled into a tributary of the Occoquan Reservoir, threatening the water supply of nearly 700,000 users in the Washington, D.C. metropolitan area. During the following weeks a major effort was made by federal, state and local governments and by the pipeline company, to contain the spill, remove the product from both land and water, and to ensure the safety of the public water supply.

During the crisis, staff of the Occoquan Watershed Monitoring Laboratory (OWML) helped to establish an emergency water quality monitoring plan and to develop response protocols based upon levels of contaminant measured at the water supply intakes. Analyses used to track the contaminant in the reservoir included odor, total fluorescing organics and total chromatographicable organics. The contaminant eventually reached the raw water intakes, and powdered activated carbon was then employed in the treatment processing scheme. No kerosene was ever detected in the finished water.

SPATIAL DISTRIBUTION OF HEAVY METALS IN SEDIMENTS FROM HAMPTON ROADS, CHESAPEAKE BAY, AND THE INNER VIRGINIAN SHELF. Joseph H. Rule, Department of Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

Selected heavy metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) were measured on acid extracts of sediment samples from the Elizabeth River, Hampton Roads Harbor, Thimble Shoals and Cape Henry Shipping Channels and the proposed Norfolk Disposal Site for dredged sediments. Metal levels were lowest in the Norfolk Disposal Site sediments and increased in samples taken from the Chesapeake Bay shipping channels, Hampton Roads Harbor, and the Elizabeth River, in this order. Samples from the upper part of the Southern Branch of the Elizabeth River contained lower levels of metals than the more highly industrialized lower reaches. The distribution of most metals were described by a log-normal function. Cumulative frequency plots indicated two populations exist for most metals. The technique of metal vs. Fe plots was used to delineate sediments with natural metal levels from those affected by anthropogenic sources. (Aided by NOAA Grant NA79AA-D-00026)

USE OF A BLOOD ENZYME AS AN INDICATOR OF CHRONIC LEAD CONTAMINATION IN RAINBOW TROUT. G. J. Sandone* and J. J. Ney. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

In humans, the enzyme delta-amino levulinic acid dehydratase (ALA-D) is inhibited in the pathway of heme synthesis by lead. It has been suggested that determination of ALA-D activity might be a useful technique to define chronic lead contamination in a variety of vertebrates, including fish. We tested this hypothesis by comparing ALA-D activity in rainbow trout from two pristine and two lead-contaminated streams. Highways served as sources of contamination; previous research in this laboratory has documented the relationship of highway usage and heavy metals concentrations in stream biota.

Trout were sampled quarterly from each of the four streams, and ALA-D levels were compared. Results indicate that ALA-D activity varied significantly among streams and sampling dates and was inversely related to fish length. Trout taken from one pristine stream exhibited the lowest levels of enzyme activity, and ALA-D activity was highest in the roadside streams. Results are directly opposed to the hypothesis.

FACTORS AFFECTING THE VEGETATIVE RECOVERY OF A DEBRIS AVAILANCHE IN NELSON COUNTY, VIRGINIA. Rebecca Schneider* Nina Fisher*, and Judith Peatross*. Department of Environmental Sciences, Univ. of Virginia, Charlottesville, VA. 22903

In August 1969, Hurricane Camille inundated Nelson County Virginia with 28 inches of rain in an 8 hour period. The associated floods resulted in hundreds of debris avalanches which cleared sections of slopes down to bedrock. Revegetation and soil development over the past 12 years differs markedly between various sites as well as within a single debris avalanche slope. Recovery covers a spectrum of micro environments from lichen and moss on exposed rock faces to dense tree stands on a thick soil substrate.

This study examines the factors which have controlled recovery on a single debris avalanche above Davis Creek, Nelson County. Physical influences including slope angle, soil depth and presence of boulders or fractures, were examined in each of 104 one square meter quadrats. Extent of recovery was established by measuring vegetative growth.

Multiple regression techniques were used to determine which factors contribute to the rapid recovery of the debris avalanche. Important features appear to include the relationship of the site to capture and retain soil. These factors facilitate the revegetative processes on a debris avalanche.

SENSITIVITY ANALYSIS OF UPWELLING THERMAL RADIANCE IN PRESENCE OF CLOUDS. S.V. Subramanian* and S.N. Tiwari, Dept. of Mech. Eng. and Mechanics, Old Dominion University, Norfolk, VA. 23509, and J.T. Suttles*, NASA Langley Research Center, Hampton, VA. 23665

Total upwelling radiance at the top of the atmosphere is evaluated theoretically in the presence of clouds. The influence of cloud heights, thicknesses and different cloud covers on the upwelling radiance is also investigated. The characteristics of the two cloud types considered in this study closely correspond to altocumulus and cirrus with the cloud emissivity as a function of its liquid water (or ice) content. For calculation of the integrated transmittance of atmospheric gases such as H₂O, CO₂, O₃, and N₂O, the Quasi Random Band (QRB) model approach is adopted. Results are obtained in three different spectral ranges and are compared with the clearsky radiance results. It is found that the difference between the clearsky and cloudy radiance increases with increasing cloud height and liquid water content. This difference also decreases as the surface temperature approaches the value of the cloud top temperature.

THE DISTRIBUTION OF IODATE IN THE JAMES RIVER AND THE LOWER CHESAPEAKE BAY. E. Takayanagi and G.T.F. Wong*, Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508.

Salinities and the concentrations of iodate were measured in surface waters of the James River and the southern Chesapeake Bay. Concentrations of iodate ranged from below detection limit to $0.241 \mu\text{M}$ with salinities 0 to 32.7 o/oo , respectively. Although the concentration of iodate, in general, increased with increasing salinity, a linear relationship has not been observed. The observed concentrations fell below the theoretical mixing line of a conservative tracer between river water and seawater, and may be represented either as a concave curve or as two linear lines. In the former case, the removal of iodate during estuarine mixing is implied. In the latter case, a mixing process involving three end-members would have to be invoked. The three end-members may be Atlantic Ocean water, Chesapeake Bay water and James River water with salinities and concentrations of iodate of 32.7 o/oo , 17 o/oo and 0 o/oo , and $0.241 \mu\text{M}$, $0.06 \mu\text{M}$ and undetectable amount, respectively.

THE EFFECTS OF ISOTROPIC MULTIPLE SCATTERING AND SURFACE ALBEDO ON THE PHOTODISSOCIATION FREQUENCIES OF TROPOSPHERIC SPECIES. S.N. Tiwari and T.R. Augustsson*, Dept. of Mech. Eng. and Mechanics, Old Dominion University, Norfolk, VA 23508.

In order to accurately calculate photodissociation frequencies of troposphere species, radiation into and through the troposphere must be determined. Most tropospheric photochemical models use the so called Leighton approximation, which effectively represents a one-stream approach, to calculate the radiation field. The present study shows results calculated with a one-dimensional time-independent tropospheric photochemical model that has been coupled to a radiative model that accurately accounts for all important physical processes in the troposphere: (i) Rayleigh and Mie scattering, (ii) surface albedo and (iii) pure absorption by trace gases such as ozone. Results comparing the Leighton approximation to the multiple scattering calculations indicate that key photolytic processes, such as photodissociation of ozone, are significantly altered when the more realistic radiative model is used. Differences as large as factors of three and four were obtained using an albedo of 0.25. This work was supported by NASA Langley Research Center through cooperative agreement NCC1-30.

TEMPORAL VARIATIONS OF NUTRIENT CONCENTRATIONS IN THE LOWER CHESAPEAKE BAY AND THE INNER VIRGINIAN SHELF. J.F. Todd and G.T.F. Wong*, Dept. of Oceanography, Norfolk, VA 23508.

Salinity and dissolved nutrient concentrations were measured in surface waters of the lower Chesapeake Bay and Inner Virginian continental shelf from March to October of 1980. The objective of this research was to investigate the Chesapeake Bay outflow on the water quality and productivity of the Inner Virginian shelf.

Lower Chesapeake Bay water contains higher concentrations of nutrients than offshore waters. Thus, Chesapeake Bay is a potential source of nutrients to the adjacent shelf waters.

Within 6 hours, variations in salinity concentrations of 5 o/oo , ammonia by a factor of 7, nitrate by a factor of 5, and phosphate by a factor of 2, were observed at a station in lower Chesapeake Bay. Silicate varied by a factor of 35 within one week at the same station. Similar nutrient variations were observed from June to October, 1980.

Due to the similarities in the relative magnitudes of the changes in salinity and nutrient concentrations in the various time scales, it is difficult to establish seasonal variations of these parameters and to accurately measure the flux of nutrients to the shelf waters.

Pb-210 AND Cs-137 GEOCHRONOLOGY AND THE DISTRIBUTION OF SELECTED HEAVY METALS IN A CORE FROM BACK BAY, VIRGINIA. J.F. Todd and G.T.F. Wong*, Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508.

The concentrations of Pb-210, Cs-137, Cu and Zn at various depths in a core from Back Bay, Virginia were measured. The concentration of Pb-210 was uniform in the first 4 cm of sediment, and then decreased exponentially to a depth of 18 cm, where a sharp decrease to a constant level was observed. A sedimentation rate of 6.2 mm/yr was calculated from the data between 2 and 18 cm. Cs-137 concentrations of 1 pCi/g were found in surface sediments. The concentration decreased to below detection limit at 18 cm depth. If the horizon at 18 cm is assumed to represent 1954, the year at which atmospheric deposition of Cs-137 became detectable, a sedimentation rate of 7 mm/yr can be calculated.

Cu and Zn varied from 7 and $37 \mu\text{g/g}$ in surface sediments to 6 and $34 \mu\text{g/g}$ at 12 cm, respectively. The concentrations of both metals in the surface sediments were lower than those observed in James River sediments by a factor greater than 2, suggesting a possible higher anthropogenic input to the James River sediments. Fluxes of Cu and Zn to the Back Bay core were calculated to be 2 and $12 \mu\text{g/cm}^2/\text{yr}$, respectively.

ENRICHMENT OF ORGANIC CARBON AND CHLOROPHYLL A IN THE SURFACE MICROLAYER OF COASTAL FRONTAL ZONES. D.J. Velinsky, T.L. Wade, Dept. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508.

Surface microlayer (top 150 μm) and subsurface (20cm below the surface) water samples were collected from estuarine frontal zones at the mouth of Chesapeake Bay and analyzed for total organic carbon (TOC), chlorophyll a (Chla) and phaeo-pigments (pp). The concentrations of these parameters show large variabilities, but several trends are still apparent. The concentrations of TOC and pp were generally higher in the surface microlayer than in subsurface waters, while Chla concentrations were approximately the same at both depths. The concentrations of TOC, Chla, and pp are generally highest at the front and decrease away from the frontal interface. This indicates that chemical and biological materials first collect at the sea surface, then convergence of water masses at frontal zones cause these materials to concentrate at the frontal interface. These processes may also concentrate anthropogenic organic materials such as petroleum hydrocarbons at the frontal interface.

THE TEMPORAL AND SPATIAL DISTRIBUTION OF ANTHROPOGENIC HYDROCARBONS ENTERING LOWER CHESAPEAKE BAY IN ASSOCIATION WITH BULK PRECIPITATION. David B. Webber* and Terry L. Wade, Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508.

Bulk precipitation samples were collected at four stations surrounding lower Chesapeake Bay from November 1980 to April 1981. Hydrocarbon concentrations in these samples were highly varied and ranged from less than 2 to $298 \mu\text{g/L}$. Samples collected during the winter months reveal a much greater concentration of anthropogenic hydrocarbons than do the samples collected in the spring months. However, these spring samples showed a predominance of odd chained n-alkanes most likely originating from pollen. This indicates seasonal trends of hydrocarbon concentrations in association with atmospheric fallout.

Hydrocarbon concentrations averaged $110 \mu\text{g/L}$ in the urban site at Norfolk and $28 \mu\text{g/L}$ in samples from the remaining non-urban sites. These concentrations are several times greater than typical hydrocarbon levels found in lower Bay waters and indicate that spatial distribution is also a very important factor to be considered.

This preliminary study has demonstrated that the atmosphere may be a significant source of hydrocarbons to the Bay. Further studies are needed in order to gain more complete seasonal data on these inputs.

METEOROLOGICAL ASPECTS OF USING LIDAR FOR
ATMOSPHERIC POLLUTANT SENSING. S. M. Zubrick*,
Dept. of Geophysical Sciences, Old Dominion Univ.,
Norfolk, VA 23508

The three dimensional ozone structure downwind
of industrialized urban areas is not fully char-
acterized by present methods. Proper control
strategies require the impact of transported urban
ozone on downwind areas. The NASA/Langley Re-
search Center experimental airborne LIDAR system
remotely senses vertical ozone and aerosol pro-
files within the planetary boundary layer afford-
ing the capability to adequately characterize an
urban ozone plume.

Discussions of the diurnal planetary boundary
layer evolution under fair-weather high pressure
systems are used to qualitatively explain the
three dimensional ozone structure. Airborne LIDAR
flight strategies are developed that would char-
acterize an urban ozone plume and provide a useful
data base for ozone modeling efforts.

Geology

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

LAMELLAE IN SOILS: MODERN SECONDARY STRUCTURES. C.R. Berquist
Va. Div. of Min. Res., Dept. of Geology, College of William
and Mary, Williamsburg, Va. 23185

Although lamellae are commonly found in sandy soils, little is known of their genesis. A few observations can be added to help in understanding their formation.

Near Chincoteague, Va. lamellae and human graves were found together in the sides of a sand pit. The sediments at this location are correlative with Norfolk or younger units. These lamellae consist of irregular but continuous horizontal brown sheets of clay-enriched sand in a clean, fine- to medium-grained sand. In outcrop these sheets appear as bands and occur between $\frac{1}{2}$ m. and $3\frac{1}{2}$ m. below ground level. Above and within the graves the lamellae range in thickness from 2 to 4 mm. and are spaced from 5 to 10 cm. apart. As much as 1.5 m. below the graves the (older) lamellae are thicker (0.5 to 2 cm.) and more closely spaced (2 to 7 cm.). Since the upper lamellae pass from above the human remains into undisturbed soil adjacent to the grave, they have formed since burial of the individual or within about the last 160 years. This date is based on finding machine-cut nails in one of the caskets.

PRELIMINARY SURFICIAL GEOLOGY OF THE VIRGINIA COASTAL PLAIN SOUTH OF THE JAMES RIVER. C.R. Berquist (Va. Div. of Min. Res.), G.H. Johnson and K.M. Farrell* (Va. Div. of Min. Res.), Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185.

Regional investigation has shown that a clayey silt (Sedley Formation of Moore, 1936) is a mappable upper member of the Yorktown Formation. West of the Surry scarp the feldspathic, fining upward Bacons Castle Formation (fluvial-deltaic ?) unconformably overlies the Yorktown and is a major surficial unit. Sediments deposited by repetitive transgressive-regressive cycles occur east of the Surry scarp and along rivers. The Windsor Formation unconformably overlies the Bacons Castle and older units. It includes sand and clayey silt members (barrier-lagoonal "Mooring units" of Oaks and Coch, 1973) in the vicinity of the Surry scarp. A fining upward sequence (nearshore marine to lagoonal) of the Windsor Formation occurs east of the scarp. Two fluvial-estuarine, fining upward sequences occur along major rivers and are younger than the Windsor and older than the Norfolk Formation. Previously, one of the units was mapped as Norfolk, the other as Windsor. Two late Pleistocene marine-barrier sand complexes, the Norfolk and Kempsville-Sandbridge Formations of Oaks, occur between the Suffolk and Hickory scarps and between the Hickory and Oceana ridges, respectively. Possibly a younger thin silt and sand sequence lies between the ridges and the Holocene beach-dune-bay deposits along the coast.

PETROLOGY OF AN ANDESINE ANORTHOSIDE BODY NEAR MONTPELIER, VA. K. L. Bick, Dept. of Geology, Coll. of William and Mary, Williamsburg, VA 23185.

The mineralogy, textures and chemical composition of an andesine anorthosite near Montpelier, VA were studied to characterize the intrusive and determine the effects of metamorphism of the body.

The anorthosite body consists of two phases: a coarse, gray nonfoliated anorthosite and a white highly granulated, foliated anorthosite. The essential minerals of the coarse or primary anorthosite were plagioclase (An36), pyroxene, quartz and apatite before later alteration introduced amphibole and chlorite as a pseudomorphic replacement of the pyroxene. The andesine occurs in two textural varieties: antiperthite and myrmekite. Accessory minerals include ilmenite, rutile, garnet, biotite and sphene. The granulated anorthosite is composed of plagioclase (An34), quartz, microcline and biotite.

Anorthosite was probably emplaced in the schist through passive intrusion during the pC. After crystallization the area was subjected to intense regional metamorphism. Granulation and recrystallization of the primary anorthosite produced the granulated anorthosite.

TRACE MERCURY IN SURFICIAL MATERIALS ASSOCIATED WITH SULFIDE DEPOSITS NEAR MINERAL, VIRGINIA. J. R. Bosco*, and G. D. Robinson, Dept. of Geology, James Madison Univ., Harrisonburg, Va. 22807

Hg offers certain potential advantages in exploration because its volatility allows diffusion through rock pore spaces. This study was undertaken to test the exploration feasibility of determining Hg in Mn-Fe oxide coatings on stream alluvium. Such coatings act as scavengers for several metals, and are therefore important to geochemists.

Soil samples and coated pebble samples were collected near Mineral, Va., from areas overlying sulfide mineralization as well as from barren country rock. Based upon a partial digestion technique, Hg in the coatings is distinctively enriched near the mineralized zone, particularly when concentrations are expressed as a ratio to Fe. Cu/Fe produces a similar although less well-defined pattern but coating Zn is not a reliable indicator of mineralization. The opposite trend is evident in the soil where both Cu and Zn clearly delineate the mineralized zone, but not Hg.

The fact that Hg concentrations in coatings indicate the mineralized zone but soil concentrations do not is considered to be significant because determination of soil Hg is a generally accepted exploration technique, although erratic results sometimes occur. Results of this study suggest that even in areas where soil Hg concentrations are erratic, its concentration in alluvial coatings may still delineate mineralization.

NEW ASPECTS OF EXPLORATION FOR VOLCANOGENIC MASSIVE SULFIDES IN THE ANDERSONVILLE-WILLIS MOUNTAIN AREA, CENTRAL PIEMONT. Richard S. Good, Virginia Division of Mineral Resources, Box 3667, Charlottesville, VA 22903.

A series of massive and massive-disseminated Zn- and Cu-bearing pyrite-pyrrhotite lenses of potential economic interest was discovered near Andersonville in the 1950's. Drilling on two zones showed 794,000 tons of 4.6% Zn, 0.60% Cu and 555,500 tons of 4.87% Zn and 0.98% Cu. The sulfides are folded and stratified within the dominantly mafic unit of the Lower Cambrian Chopawamsic Formation. Numerous thin ferruginous quartzites (recrystallized distal volcano-genic cherts) are also stratabound within the Chopawamsic and are proximal to the sulfide zones or grade into them. Geochemical anomalies of sand-sized sediments of Fe, Cu, Zn, Pb, Co, and Mn are strikingly associated with Fe-quartzites. Known and also new sulfide zones were clearly indicated by refined geochemical techniques. The Cattail Creek area is one of the new anomalies recommended for drilling. The stratabound sulfide bodies were formed on the ocean floor from hot brines and "smoker plumes" in a confined, back-arc basin close to a subduction zone. Gold and kyanite found in post-Chopawamsic quartzites and schists are also interpreted as being volcanogenic, but both minerals were reworked by fluvial or shallow tidal processes. The Willis Mountain kyanite deposits contain accessory pyrite-gold-hematite-fuchsite-rutile + topaz and show similarities to the Cambrian (?) Haile and Brewer volcanogenic gold deposits of the Carolina slate belt, S. Carolina.

GEOMORPHIC EVIDENCE FOR MULTIPLE EPISODES OF DEBRIS AVAILANCING IN CENTRAL VIRGINIA. R. C. Koehler*, R. A. Johnson*, and R. J. Wayland*. Dept. of Environmental Sciences, Univ. of Virginia, Charlottesville, VA 22903

Heavy rains associated with Hurricane Camille in August 1969 triggered hundreds of debris avalanches on steep slopes in Nelson County, Virginia. Debris avalanching appears to be a major denudational process in the central Appalachians. These events are typically associated with catastrophic floods in master streams in the area.

Debris avalanche deposits partially preserved on alluvial fans in the Davis Creek watershed show evidence of up to three episodes of debris avalanching. The deposits are very poorly sorted mixtures of granite-gneiss cobbles and boulders with a sand and mud matrix. Each deposit has an erosional base and may be inversely graded. Criteria for recognizing individual events include buried soil horizons, texture, mineralogy, grading, clast weathering, matrix clay content, and induration.

Davis Creek floodplain deposits contain sediments from at least two major floods, each separated by well-developed buried soil horizons. The 1969 flood sediments contain clasts having average intermediate diameters an order of magnitude coarser than the underlying deposits, which suggests that the Camille flood was of considerably greater magnitude than earlier floods. Inversely graded segments and transport of large rip-up soil clasts intact suggest that the flow was similar to a fluid debris flow.

SEDIMENT BUDGET AND NOURISHMENT AT VIRGINIA BEACH, VIRGINIA: 1979-1980. M.C. KAY and G. AUGUST*, Dept. of Oceanography, Old Dominion University, Norfolk, Virginia 23506

A study was conducted at Virginia Beach, VA to determine the annual sediment budget of an 8 km stretch of shoreline extending from Rudee Inlet northward to Cape Henry, VA. 12 profile stations were surveyed monthly for 13 months from Sept. 1979 to Sept. 1980. Profiles extended from backshore seawall or dune line to mean low water, and were obtained by a method similar in principle to the use of Emery Rods. The total of 216,000 m³/yr. of nourishment material was placed on the southern 4.6 km section of the study area, but it was not possible to subtract out the effects of artificial nourishment from the budget to determine the natural unenriched state of the beach.

The overall study area experienced net accretion of 40,000 m³/yr., the southern nourished section underwent net erosion of 6,000 m³/yr., and the northern unenriched section showed 46,000 m³/yr. net accretion. These annual net sand volume changes were on the same order of magnitude as monthly net accretion and erosion; overall study area ranged -45,000 to +37,000 m³/month, nourished section ranged -35,000 to +28,000 m³/month, and unenriched section ranged -27,000 to +32,000 m³/month.

A single storm event caused 124,500 m³ net erosion along the entire study area and thus could negate months and/or years of net accretion. Storm events may also explain the lack of observed seasonal trends in accretion and erosion at Virginia Beach, Virginia.

SOME STRATIGRAPHIC DETAILS OF THE OTTERDALE SANDSTONE IN THE RICHMOND BASIN. Bruce K. Goodwin, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

The Otterdale sandstone occurs as an elongate unit extending from the Richmond basin's western margin northeastward for about 10 miles. Exposures contain very coarse-grained arkosic sandstone to arkose; pebbly, very coarse-grained arkosic sandstone; conglomerate; and minor silty, fine-grained sandstone and siltstone. The coarse-grained sandstones are commonly cross-stratified and the conglomerates commonly occur at the base of channels cut into the finer grained rocks. A few boulders of granite and gneiss are sparsely disseminated in the sandstones.

A 1514 foot measured section of the Otterdale sandstone was obtained from a cored drill hole .4 mile from the basin's western margin. The bottom third of this section consists of 40% pebbly to conglomeratic, very coarse- to coarse-grained sandstone; 7% conglomerate; 9% coarse-grained sandstone; 7% pebbly, fine-grained sandstone; 13% fine-grained sandstone; 23% silty, very fine-grained sandstone; and 1% shale. Coarse-grained sandstone and conglomeratic sandstone also dominate the upper two-thirds of the section.

Northeastward, the Otterdale sandstone becomes less conglomeratic, thinner, overlies the Vinita beds, and inter-fingers with the Vinita beds. Pebbly and arkosic, coarse-grained sandstones still dominate, but sandy siltstones become more abundant and a few thin shale beds appear.

STRUCTURAL EFFECTS ON SLOPE FAILURE OF DEBRIS-AVALANCHES IN NELSON COUNTY, VIRGINIA. L. D. Lisle* and R. C. Koehler* Dept. of Environmental Sciences, Univ. of Virginia, Charlottesville, Va. 22903.

Bedrock structure has been shown to play an important role in geomorphic processes. The bedrock structure of Davis Creek Basin, Nelson County, Virginia, was examined to determine if it had any influence on the frequency and distribution of debris-avalanches initiated by the 1969 Hurricane Camille storm. 417 joints were measured and analyzed on three debris-avalanche chutes in the basin. The basin is underlain by the Precambrian Lovington granite gneiss which has a foliation parallel to the dominant joint set orientation of N.50°E., 70°SE. The north-facing chutes have relatively smooth bedrock surfaces while the surface of the south-facing chute is irregular. No sheeting joints were observed on the south-facing chute. Its surface is oriented 40° from the dominant joint set. North-facing chutes are oriented 80° to 90° from the dominant joint set and contain sheeting joints. The north-facing chutes appear to be controlled by sheeting joints while the south-facing chute appears to be controlled by the dominant joint set. Greater surface and, therefore, higher surface friction on the south-facing chute may explain the lower failure frequency on south-facing slopes than on north-facing slopes.

BILLION-YEAR-OLD ROCKS OF THE BLUE RIDGE ANTICLINORIUM OF NORTHERN VIRGINIA: A REVIEW. James W. Clarke, U. S. Geological Survey, Reston, VA 22092

The Blue Ridge anticlinorium extends about 880 km from Georgia to Pennsylvania. From Lynchburg, Va., for about 225 km northeastward into Maryland, the anticlinorium has a central core of billion-year-old metamorphic rocks. These rocks have been mapped in detail in the Orlean quadrangle in northern Virginia. A major fault extends northeastward through this quadrangle and divides it into two different terranes. On the west, the oldest rock is the Flint Hill gneiss, which is a strongly layered and foliated granitic gneiss. It characteristically contains numerous veins of blue quartz. A Pb-207/Pb-206 zircon age of 1081 m.y. has been obtained on this gneiss. The Flint Hill Gneiss is intruded by the Robertson River Granite, which has a nearly concordant Pb-207/Pb-206 age of 701 m.y. To the east of the major fault, the oldest mappable rock unit is a biotite augen granitic orthogneiss. This gneiss carries a few xenoliths of banded injection gneiss, which could be fragments of older crust. This augen gneiss is intruded by Marshall Metagranite, which is a moderately foliated biotite granite to quartz monzonite. Characteristic of the Marshall is a bimodal grain-size distribution of the quartz at 0.2-0.3 mm and 1-2 mm. The coarser quartz is commonly blue. The Pb-207/Pb-206 zircon age obtained for the Marshall is 1010 m.y. The rocks of the Orlean quadrangle and vicinity do not contain hypersthene and hence do not appear to have reached the granulite grade of metamorphism.

CHARACTERISTICS OF SOME SOILS OF THE DISMAL SWAMP. Joseph H. Bule and Terri Manfredi Mathews,* Dept. of Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508.

Research conducted in the Dismal Swamp of Virginia during 1980 studied the soils under four different forest communities within the swamp. The soils at each site were characterized which allowed division of these into one Histosol and three mineral soil types. The profiles of the three mineral soils were found to be quite different physically from one another yet similar chemically. Chemical parameters measured on the soils include pH, cation exchange capacity and exchangeable cations. The pH of the soils are all generally below 5.0 with little variation down the profile. Cation exchange capacity is moderate to high with H^+ dominating the exchange complex. Exchangeable base cations are extremely low. Although the majority of soils in the Dismal Swamp are Histosols, this study has examined three important areas of mineral soils that exist in the swamp. All soils studied had quite variable soil properties and low nutrient status. (Aided by NSF grant no. DEB-7708609-A01)

GEOCHEMISTRY OF AN UNUSUAL CARBONATE-RICH SOIL IN ROCKINGHAM COUNTY, VIRGINIA. E. R. McFarland and W. C. Sherwood, Dept. of Geology and Geography, JMU, Harrisonburg, VA 22807.

A carbonate-rich Mollisol designated the Massanetta Series was recently mapped in western Virginia along streams draining faulted carbonate bedrock. An area in SW Rockingham County was chosen 1) to investigate the carbonate in the soil, and 2) to explain the geochemical environment. The soil profile is approximately 150 cm thick and is underlain by a coarse river gravel. Augering to 120 cm showed weakly developed A, B5 and C horizons. Carbonate content increased with depth to 65% in the C horizon where it occurs both as white powdery flakes and as hard crusty layers.

Laboratory analyses were conducted on the soil and stream waters. X-ray work showed all the carbonate to be calcite. AA analyses of the calcite yielded Mg/Ca and Sr/Ca ratios ranging from .0053 to .0008 and from .00035 to .00017 respectively. Stream water samples contained (in ppm except for pH): Ca from 120 to 170; Mg from 37.4 to 63.6; Sr from 0.8 to 1.2; and pH from 7.8 to 8.9. Hydrolysis and ionic effects were computed and the waters were found to be approximately at saturation.

Assuming that all of the groundwater entering the study area contains similar ionic concentrations, it is concluded that these waters move freely through the underlying coarse gravels, are then taken up into the finest overlying soil by capillary action, and deposit calcite due to surface evaporation.

MICA AGES AND UPLIFT HISTORY IN THE VIRGINIA PIEDMONT. D.G. Mose, Department of Chemistry and Geology, George Mason University, Fairfax, Virginia 22030, and A. Tunsoy*, Department of Geology, Florida State University, Tallahassee, Florida 32306.

Radiometric age determinations by the K-Ar and Rb-Sr techniques on biotite and muscovite in metamorphic rocks have long been used to determine the time at which a metamorphic terrane cooled to a temperature of about 300°C, below which biotite and muscovite begin to retain radiogenic argon and strontium. Recent mica age determinations in the Piedmont of central Virginia yield early Triassic ages of about 200 million years. These ages may be taken to indicate that these metamorphic rocks were at elevated temperatures for a prolonged interval following the early to middle Paleozoic metamorphic episode. An alternate possibility is that these mica ages represent a post-metamorphic interval of temperature elevation, perhaps related to crustal tension and thinning which preceded Triassic rifting and the upward movement of mantle derived magmas.

RADIOMETRIC AGES OF PLUTONS FROM THE VIRGINIA PIEDMONT

ALONG THE JAMES RIVER. D.G. Mose and M.S. Nagle*, Department of Chemistry and Geology, George Mason University, Fairfax, Virginia 22030

Rb-Sr whole-rock age determinations have recently been obtained for plutonic rocks in the central Virginia Piedmont. The oldest unit yet dated is the State Farm pluton, a granodioritic magma which intruded high-grade metamorphic rocks in the eastern Piedmont near Richmond at 1031 ± 47 m.y. ago. Metamorphosed units to the west include the Chopawamsic volcanics of middle Cambrian age (U-Pb dating: about 530 m.y. old). The Chopawamsic volcanics were intruded by the Columbia pluton of middle-late Ordovician age (Rb-Sr dating: 454 ± 9 m.y.) and the Occoquan pluton of late Cambrian or early Ordovician age (Rb-Sr dating: 494 ± 14 m.y. old). These plutonic and volcanic rocks were overlain by the Arvonian and Quantico slates of late Ordovician age (fossil dating).

CHEMISTRY OF CATOCTIN FLOWS AND FEEDER DIKES IN VIRGINIA. M.S. Nagle* and D.G. Mose, Department of Chemistry and Geology, George Mason University, Fairfax, Virginia 22030

The Catoctin Formation in the Blue Ridge Anticlinorium consists mostly of a fine grained greenstone which is thought to represent late Precambrian continental rift volcanism. The chemical composition of the greenstone has been altered from the original volcanic composition by weathering, metamorphism and spilitization. It has been demonstrated by previous workers that major elements in the Catoctin Formation have undergone chemical mobility. It can be shown that other elements are more useful for determining the original rock type of the Catoctin volcanics. Application of a cation ternary plot developed by Jensen shows that the Catoctin volcanics have a chemical composition which falls in the tholeiitic field, with a strong iron enrichment.

Numerous mafic dikes have been located in the Blue Ridge Anticlinorium. When chemical analyses of the dike rocks and the Catoctin volcanics are plotted on the ternary plot of Jensen, it is clear that the field of chemical analyses from the dike rocks is nearly identical to that of the volcanics. This suggests that the intrusions could have been feeder dikes for the Catoctin volcanics.

RICHMOND COAL: A PRELIMINARY STUDY OF ITS MINERAL CONTENT. M. A. Potts*, Dept. of Environmental Sciences, The University of Virginia, Charlottesville, Virginia 22903.

Nine bituminous coal samples from three localities along the Eastern edge of the Richmond coal basin (Triassic) were studied using X-ray diffraction powder cameras. Both unheated and heated (400°C-48 hours) samples were analyzed. Quartz and kaolinite were present in all samples. Pyrite, while not present in all the samples, was found in coals from the three areas studied. Gypsum (bassanite) and calcite were present in minor amounts in some samples. These results correlate well with earlier chemical and mineralogical data for the Richmond coal. Three samples of coal from other Triassic deposits in Virginia contained one or more of the following minerals: quartz, pyrite, calcite, and illite. All the Triassic coals studied are similar in mineral composition to Eastern coals (Pennsylvanian) studied earlier by Mitchell and Glusko (1976), which differ from Western coals that are characterized by the presence of significant gypsum and lesser amounts of calcite and pyrite.

FEEDING STRATEGIES DISPLAYED BY THE TRACE FOSSIL PALEOBULLIA IN THE PENNSYLVANIAN OF EAST TENNESSEE. K.W. Ramsey and M.F. Miller*, Dept. of Geology, Vanderbilt Univ., Nashville, TN. 37235

Occurrence of facies-restricted trace fossils, degree of bioturbation and variations in trace morphology are important aids in the interpretation of depositional environments. Surface traces in the Pennsylvanian (Fentress Fm) of the Cumberland Plateau of upper east-central Tennessee are possible remnants of the grazing trails of gastropods (Paleobullia). These traces reflect foraging patterns in the form of looping trails made in the search for food on apparently homogeneous bedding planes. The circular pattern of the loops probably reflects the most efficient means of foraging in isolated areas of high food-resource potential. The association of these trails with interference ripples and mud cracks suggests an intertidal habitat, possibly the barren zone of an intertidal lagoon. The lack of bioturbation other than the isolated trails and the uniformity of the micrograded sandstones with thin shale interbeds in which the traces occur supports this interpretation. Many trace fossils are strongly facies controlled (Seilacher, 1967). Trace fossils in the Pennsylvanian rocks studied have narrow paleoenvironmental ranges. In addition, the trace fossils give the only evidence of biologic activity in otherwise unfossiliferous rocks. In similar trace-rich Coastal Plain deposits of Virginia, biogenic structures may be useful indicators of depositional and faunal regimes.

ORIGIN OF AN EARLY CAMBRIAN(?) GRANITE IN CENTRAL VIRGINIA. Sheila F. Smith, Dept. of Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508

A 1 X 6 km granite pluton crops out on either side of the Rockfish River, Nelson County, Virginia (37°49'N, 78°46'W). Although contacts with the host Lovingson Formation and an as yet unnamed granodiorite were not observed, outcrop patterns indicate a concordant pluton.

Based on Rb/Sr ratios, the age of the granite is 570 ± 50 m.y. The initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio is 0.7229.

Mortar structures, mosaic grains and off-set albite twins in the plagioclase indicate cataclasis. The rock has undergone low-medium grade metamorphism.

Peraluminous chemistry and the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio indicate that the granite fits the criteria for an S-type granite - that is, derived from crustal sources by partial melting. (Aided by a Grant-in-Aid -of-Research, Sigma Xi, The Scientific Research Society)

A PARAGENETIC STUDY OF THE UNIQUE ELMWOOD/GORDONSVILLE MISSISSIPPI VALLEY-TYPE DEPOSITS. Robert R. Seal, II*, sponsored by W. D. Lovry. Dept. of Geological Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The Elmwood/Gordonville deposits of Central Tennessee are typical Mississippi Valley-type ores within the Lower Ordovician carbonates on the southeast side of the Nashville Dome. The ore minerals, which occur as breccia infillings, are dominated by coarse-grained sphalerite with minor amounts of galena, pyrite, and marcasite. Fluorite and barite overgrowths are common. The ore textures have been studied in doubly polished thin sections which permit transmitted and reflected light examination of the same specimen.

Paragenetic study reveals that small quartz euhedra grew along the edges of carbonate breccia fragments before zinc sulfide deposition. The sphalerite, with carbonaceous material throughout, occurs as interlocking grains that exhibit abundant growth features. At least two generations of sphalerite are present. In transmitted light, the sphalerite has a distinctive anisotropy characterized by "gridding" textures which appear similar to microcline twinning.

COLLUVIUM AND HIGH-LEVEL ALLUVIUM, CULPEPER COUNTY, VIRGINIA. G. Richard Whitecar, Department of Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

Excavations for a large oil pipeline crossing the central Virginia Piedmont exposed multiple colluvial deposits overlying high-level alluvium. The thickest ancient alluvial sediments visible in the ditch in Culpeper County rest upon bedrock terraces lying 15 meters above the Rapidan River and tributaries. The fining-upward fluvial sediments, 0 to 2.8 meters thick, are heavily weathered and impregnated with pedogenic clay to at least 2 meters depth. Rounded to sub-rounded basal gravels consist of varied non-local lithologies. Massive, very poorly-sorted colluvium blankets nearly all slopes along the pipeline transect. Commonly the colluvium is less than a meter thick and has a stoneline or other distinct boundary at its base. Coarse angular fragments of vein quartz and phyllite that are irregularly distributed throughout the silt loam matrix indicate the colluvium is of local origin. Multiple generations of over-thickened colluvium are distinguishable at two study sites based upon relationships of color, stonelines, and geomorphic position. Although no datable material was found at the sites, soil development suggests that the thick colluvial wedges are no older than late Pleistocene but that the high-level alluvium is significantly older than the colluvium. (Aided by ODRF Grant 80-964.)

MORPHOLOGIC BED CHANGES BETWEEN TWO ADJACENT GROINS DURING A TEN-WEEK PERIOD AT WILLOUGHBY SPIT, NORFOLK. Kim Zauderer*, Al Moore*, Dept. of Oceanography, Old Dominion Univ., Norfolk, VA 23508.

The zone between two adjacent groins in an extensive groin field was selected for a study of morphologic variations of the bed above and below Mean Low Water (MLW). The bathymetric data were obtained using a profiling method. Eight surveys were made between 12 May and 22 July, 1980. Results indicate that morphologic changes which occur below MLW are quite different in character from those above MLW.

An inner bar formed during the profiling period in the eastern nearshore zone of the study area. Data also revealed a trough located near the end of the groins and parallel in trend to the shoreline. Adjacent and bayward of this trough a bar occurred which also trended parallel to the shore. Elevation changes of ± 0.5 m were commonly observed between sampling days. The data suggest that regions within the profiled area change at different rates in response to changing wave conditions; moreover, the offshore trough and bar may respond to the spring tide cycle. The nearshore region from MLW to the trough responds quickly to daily wave conditions. The beach foreshore and backshore respond to more energetic wave conditions.

Materials Science

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

THE MELTING BEHAVIOR OF MICROCRYSTALS OF LEAD AND ALUMINUM.

C. L. Allen* and W. A. Jesser, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

TEM studies of the melting behavior of small lead and aluminum particles were performed in-situ. A melting point that decreases with decreasing particle radius was observed for lead. This size-dependent melting can be expressed as a nearly linear relationship between melting temperature and inverse particle radius for particles with diameters of 100 Å and more. For the size range of 60 to 100 Å in diameter, a steeper slope is shown by the data. Furthermore, lead particles of 30 to 60 Å in diameter exhibit a melting temperature above that of large particles when lead oxide is present. These trends are consistent with the experimental work of others. In the preliminary studies of aluminum, the particles reacted with the substrate and no quantitative melting point data was obtained. (funded by Army Research Office)

EXPERIMENTAL INVESTIGATION OF THE GAS BUBBLE MODEL OF HELIUM EMBRITTLEMENT.

J. L. Bennetch and W. A. Jesser, Materials Science Dept., Univ. of Va., Charlottesville, Va. 22901.

In a fusion reactor environment, helium ions and neutrons from the plasma that strike the containment wall of the reactor can cause a number of serious materials problems, including loss of ductility or embrittlement.

The phenomena of helium embrittlement in type 316 stainless steel foils were studied by in-situ tensile testing of foils in a 500 kV high voltage electron microscope (HVEM) attached to a linear light ion accelerator used at 80 kV.

In order to examine the microscopic effects of helium on ductility, the nature of cracks that nucleated in and propagated through irradiated tensile samples was carefully studied in light of current theories on helium embrittlement. These theories have various critical parameters incorporated in their equations. Among these are concepts of critical cavity diameter d , and spacing L , cavity internal pressure P and area fraction of grain boundary covered by cavities, a_g . For test temperatures above 550° C, it was found that, contrary to expectations, a_g , d , L and P are apparently not critical parameters which lead to brittle intergranular fracture. Below that temperature, however, there was determined a critical d and L for the onset of brittle fracture. In this temperature region bubbles on the grain boundary may be slightly overpressurized but even in this case no critical a_g was found.

DAMAGE DEVELOPMENT MECHANISMS IN NOTCHED COMPOSITE LAMINATES UNDER COMPRESSIVE FATIGUE LOADING.

H. F. Black*, Eng. Sci. and Mech. Dept., Va Polytechnic Inst., Blacksburg, VA 24061.

An investigation of the damage development mechanisms in notched graphite epoxy composite laminates under compressive fatigue loading is presented. The variation of damage development in two different laminate configurations and the effects of damage on material properties is observed. Several nondestructive investigation techniques were used to monitor damage during loading which included: X-ray radiography, ultrasonic C-scan, ultrasonic attenuation, acoustic emission, and stiffness change. In addition, some damaged specimens were sectioned to aid in the interpretation of the nondestructive data.

The investigation was conducted on AS/3501-6 graphite epoxy laminates with two stacking sequences:
· (±45, 0₂, ±45, 0₂, ±45, 0, 90)_{2S}, (48 plies)
· (±45, 90, -45, ±22.5, -67.5, -22.5, ±67.5, ±45, ±67.5, ±22.5, -67.5, -22.5, ±67.5, ±22.5, 0₂, ±22.5)_S, (42 ply)

Several specimens of each laminate type were quasi-statically loaded to failure to determine the ultimate compressive strength. Fatigue tests were run at 60, 70 or 80 percent of the ultimate strength for a duration of either 600,000 cycles, 10⁶ cycles, or failure.

TECHNIQUES FOR THE DETERMINATION OF THE THERMAL CONDUCTIVITY OF SMALL FIBERS AND FILMS.

L. J. Adams and R. E. Barker, Jr., Dept. of Materials Science, Univ. of Va., Charlottesville, Va., 22903.

Recent years have seen intense interest in polymeric "one dimensional" extended chain conductors and semi-conductors such as polysulfur nitride and polycacetylene. Materials of this type are expected to have interesting anisotropic thermal properties. Although it is not yet known whether their electrical conductivities are due to electrons or to ions, extended chain polymers such as poly-paraphenylene benzobisthiazole (PPBT) and polyparaphenylene terephthalamide (Kevlar) are expected, because of their high axial modulus $Y_{||}$ to have an axial conductivity $K_{||} \approx 0.33 \text{ c.u.} (Y_{||})^{1/2} \approx 1 - 10 \text{ W m}^{-1} \text{ K}^{-1}$ due to "lattice" vibrations. C_A is the product of heat capacity and the phonon attenuation length. Transverse thermal conductivities of fiber forming materials are expected to be the usual values for insulating polymers, namely $\approx 0.3 \text{ W m}^{-1} \text{ K}^{-1}$. Efforts to develop techniques for the measurement of $K_{||}$ and K_{\perp} for fibrous materials will be discussed. For example, great difficulties in the determination of $K_{||}$ result from the large heat exchange coefficient ($h \approx 200 \text{ W m}^{-2} \text{ K}^{-1}$) between small fibers and thin surrounding space. Our most successful attempts to date have utilized small thin films for the determination of $K_{||}$ followed by an adaptation of a method due to de Senarmont to determine the ratio of $K_{||}/K_{\perp} = (b/a)^2$ on wax coated films exposed to a "point" heat source. The wax melts into an elliptical pattern $2a \times 2b$. The observed K-ratios are near 6 for PPBT. (Funded by U.S. Air Force - OSR-80-0014)

ELECTRICAL CONDUCTIVITY OF HIGHLY ANISOTROPIC FIBERS AND FILMS OF POLY(P-PHENYLENE BENZOBISTHIAZOLE). D. Y. Chen* and R. E. Barker, Jr. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901.

Due to its molecular geometry poly(p-phenylene benzobisthiazole) tends to form an extended chain conformation. This tendency leads to an extreme anisotropy of mechanical and electrical properties. Experimental data, which will be discussed, reveal that the axial conductivity ($\sigma_{||}$) is 10^5 times larger than the transverse conductivity (σ_{\perp}). This large ratio along with the fact that the conduction is ohmic up to at least 1.2×10^5 V/m, is thought to imply one dimensional electronic conductivity. The presence of the "as received" acid content of samples affects the value of electrical conductivities. After washing in ethyl alcohol and then drying, PBT tends toward a value of electrical conductivity which is about 1/5 of the value for an untreated sample. On the other hand a sample treated in a solution of ammonium hydroxide tends to increase its electrical conductivity to a much higher value. Thermal treatment (e.g. oven drying) also reduces electrical conductivities to lower values. In this paper some results will be discussed of special techniques which have been developed for measuring electrical conductivities of very small samples (10 to 40 μ m diameter for fibers). (Work supported by the U.S. Air Force Grant AFOSR-80-0014.)

CHARACTERIZATION OF PRECIPITATES IN V-20Ti ALLOY. S.A. Hackney* and K.R. Lawless. Dept. of Materials Science, Thornton Hall, Univ. of Va., Charlottesville, Va. 22903

A study of the low pressure oxidation of V-20Ti alloy has been carried out in-situ using a Hitachi Millon Volt Electron Microscope. The reaction temperatures have ranged from 300°C to 800°C and the O_2 pressure has been regulated at 3×10^{-5} torr. The results show that there are two simultaneous reaction pathways. The selected area electron diffraction patterns taken during oxidation indicate that as oxygen goes into solution, small crystallites of V_2O_3 are formed. There is evidence that at long reaction times or higher temperatures large TiO precipitates are formed by Ti reacting with the dissolved oxygen.

DEVELOPMENT OF TECHNIQUES TO STUDY VAPOR DIFFUSION AND SOLUBILITY IN FIBERS AND FILMS OF POLY(P-PHENYLENE BENZOBISTHIAZOLE). W. S. Huang and R. E. Barker, Jr., Materials Science Dept., U.Va., Charlottesville, Va. 22901.

The study of the transport properties of polymers has added to the understanding of relations between macroscopic and microscopic properties. Little is known about transport properties in PET and related extended chain polymers, which should be interesting due to their anisotropic character. This work deals with the determination of diffusion coefficients D and sorption coefficients. It is part of a study that includes the determination of electrical and thermal conductivities of the same materials. PET samples are available only in limited quantities as fine fibers (~ 20 μ m diameter) and thin narrow film, therefore we have focused attention on the development of sensitive techniques for such samples. Later, spectrophotometric and electron microscopic analytical techniques will be used, but up to the present time an apparatus based on a classical sorption balance with a sensitive quartz spring in a thermostated evacuable chamber has seemed the most suitable approach. Problems of interpreting the sorption balance data for anisotropic fibers with possible concentration dependencies of the pre-exponential factor D_0 and the activation energy E_a will be discussed along with related matters. (Funded by U.S. Air Force - OSR-80-0014)

CONSTRUCTION OF A QUANTITATIVE LOAD-ELONGATION SINGLE TILT, HOT TENSILE STAGE FOR HVEM USE. R.D. Gerke* and W.A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Helium embrittlement in fusion reactor first wall material is studied by in-situ tensile testing over various temperatures in a high voltage electron microscope (HVEM) with an attached accelerator. The design of a tensile rod with load-elongation and high temperature capabilities is a useful tool to study the mechanisms of helium embrittlement. The tensile rod is operated by a hydraulic system which restrains a spring. The actual pulling force is provided by the spring. The hydraulic system consists of two fluid-filled bellows interconnected with tubing and valves. A slow metering valve governs fluid flow between the bellows which in turn controls elongation rate. A round 3.5 mm diameter heating element positioned under the tip of the stage allows for studies at temperatures up to 700°C. Helium beam specimen current is monitored through use of the thermocouple also mounted at the tip of the electrically insulated rod. Load-elongation measurements can be determined by use of two transducers: a linear variable differential transformer (LVDT) used to determine elongation and total pulling force and a pressure transducer used to determine load exerted on the sample. (Funded by Office of Fusion Energy, Dept. of Energy)

IN-SITU HVEM OBSERVATIONS OF HIGH TEMPERATURE FRACTURE MECHANISMS IN NEUTRON-DAMAGED 304 STAINLESS STEEL. T. Hanamura and W. A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

The purpose of this experiment is to investigate the nature of crack propagation during tensile testing of irradiated materials containing voids or bubbles. In this experiment five specimens were investigated. All unirradiated and helium-irradiated specimens were Type 316 stainless steel annealed at 1000°C for one hour. One specimen was neutron irradiated 304 stainless steel. It was found that the crack angle was small in the helium-irradiated sample. Scissors-like crack propagation occurred at higher temperatures (400°C) in both helium-irradiated and unirradiated specimens. Crack tip angle is correlated with crack tip radius and both decrease in front of the grain boundary. Grain boundary sliding occurred in both helium-irradiated and unirradiated specimens. The neutron-irradiated specimen showed typical intergranular crack propagation at 400°C while He-irradiated and unirradiated specimens showed transgranular crack propagation at 400°C. The neutron-irradiated specimen showed a sharp crack angle and a very small crack tip radius compared to the other specimens.

CHARACTERIZATION OF SMALL Pb-Bi ALLOY PARTICLES. W.W. Gil* and W. A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Specimens of Pb-Bi alloy microcrystals were prepared by co-vapor deposition of each element onto a heated amorphous carbon substrate. The deposition was performed in a diffusion-pumped vacuum system ($\sim 5 \times 10^{-4}$ Pa) with the substrate at $\sim 200^\circ\text{C}$. After deposition, an additional layer of protective amorphous carbon was deposited on the specimen to limit oxidation and other contamination. The overall composition of the specimens ranged from 20 to 80 wt.% bismuth and the particle diameters ranged from 5 to 500 nm. The characterization of the specimens was performed in a Philip's E.M. 400. The structure and average composition of the specimens were determined by selected area diffraction and X-ray microanalysis. Determination of the structure and composition of individual microcrystals was accomplished by convergent beam diffraction and STEM X-ray microanalysis. The specimens were found to contain two or three of the three stable solid phases found in the bulk Pb-Bi system. Most of the individual microcrystals analyzed by convergent beam diffraction contained pairs of phases. The compositions of these microcrystals were found to be size-dependent, with the smaller microcrystals being Bi-smooth-rich. The microcrystals were also quickly electron beam heated by removing the condenser aperture of the microscope. It was found that, during heating, the relative evaporation rates of the Bi and Pb were very dependent on the composition of the particles and therefore on the phases present.

STRESSES IN MULTIPLE-PIN CONNECTORS: A PHOTOELASTIC APPROACH. M. W. Hyer*, and D. H. Liu*, Engineering Science and Mechanics, Virginia Tech, Blacksburg, Va. 24061.

For some time there has been an interest in the effects of through-the-thickness holes and other discontinuities in plates. From a practical point of view there is generally no way discontinuities can be avoided, particularly in regions where plates must be connected to other structural members. Most connectors use pins, bolts, or rivets in the holes to serve as the actual connector. Photoelastic models can be used to effectively analyse the stresses in connector regions. Specific interest in this study centers on models of two-hole connectors in a double-lapped joint configuration. The two holes are in tandem, or series, and the joint is subjected to tensile loads along the line joining the centers of the two holes. The fasteners are snug-fitting pins. The photoelastic models are constructed of photoelastic materials and a transparent acrylic which is not photoelastic but which has the same elastic properties as the photoelastic material. In this manner, the photoelastic fringe patterns in the inner laps can be seen through the acrylic outer laps. Because of the ease of fabricating photoelastic models, many joint geometries can be studied by fabricating joints of various widths and lengths. The study shows that the stresses at one hole can be about twice as great as the stresses of the other hole. This trend is dependent on joint geometry.

The work supported herein is sponsored by the NASA Langley Research Center, Donald J. Baker, Jr. grant monitor.

CARBON ATMOSPHERE NEAR AN EDGE DISLOCATION IN IRON. A.S. Nandedkar* and R.A. Johnson. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901.

The distribution of carbon atoms near a $\frac{1}{2}\langle 11 \rangle\{110\}$ edge dislocation in iron is calculated using an existing interaction energy relationship between point defects and an edge dislocation based on isotropic elasticity theory. Empirical correction factors for energy relations are used inside the core. The interaction between carbon atoms is neglected.

A block of fixed size, periodic along the dislocation line, is taken as the computational cell, and the location of octahedral sites in the vicinity of the dislocation is determined from an elastic dislocation model. The Fermi-Dirac distribution function is then used to compute occupation probabilities of these sites. Due to the shape interaction, these probabilities depend upon the orientation direction of each site.

Finally, this atomistic model is used to compute the breakaway stress of an edge dislocation in iron from a carbon atmosphere. (Supported by NSF grant No. DMR78-07539)

ANALYTIC PREDICTIONS OF THE ANNEALING RESPONSE OF REACTOR VESSEL STEELS. A. P. Main* and B. L. Shriver, Dept. of Nuclear Engr. & Engr. Physics, Univ. of Va., Charlottesville, VA 22901.

Several of the early light water reactor plants utilized reactor vessels fabricated from steels having a relatively low toughness and are experiencing increasing embrittlement with irradiation. In these cases, the use of in-situ thermal annealing is being considered to reduce the irradiation embrittlement and, thereby ensure that brittle failure of the reactor vessel will not occur. This paper discusses the initial results of work being done at the Univ. of Va. to provide a method for predicting the embrittlement recovery resulting from thermal annealing.

The U.Va. annealing model presently assumes that there are three types of irradiation induced defects responsible for the observed embrittlement as determined from shifts in the reference transition temperature. The activation energy of diffusion and distance to a sink for each defect is different, but no other properties are defined.

The shift in the reference transition is assumed to be proportional to the square root of the density of the defects. Each defect type contributes a different amount to the embrittlement which is accounted for by the use of weighting factors. These weighting factors are determined by the chemical composition of the material.

Thus the model allows prediction of a materials response to thermal annealing if the chemical composition is known.

HIGH RESOLUTION TEM STUDIES OF FINE-GRAINED α -IRON. J. Newkirk* and H.G.F. Wilsdorf, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Polycrystalline α -iron filaments with diameters from 1000 Å to 30 μ m can be produced by the decomposition of iron pentacarbonyl. They are grown at 280° C in a magnetic field and contain 1.5 w/o C and 0.8 w/o O. This growth process results in an unusual microstructure and properties. The filaments are very strong (6-8 GPa) and have no microporosity. TEM reveals α -iron grains on the order of 100 Å in diameter with grain boundaries which appear to be non-planar and have widths of 10-20 Å. Grain orientations and shapes have been studied and will be discussed along with a comparison with grain boundaries in normally solidified alloys.

Medical Sciences

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

IN-VITRO BINDING OF PHENCYCLIDINE TO SERUM AND TISSUES FROM RAT. B.B. Bailey*, M.L. Lawrence* and B.R. Martin, Dept. of Pharmacology, Med. Col. of Va., Richmond, Va., 23298.

Previous distribution studies from our laboratory suggests that phencyclidine (PCP) has a low affinity for blood since PCP rapidly distributes from blood into tissues where it is sequestered. In order to compare serum binding of PCP to tissue binding, equilibrium dialysis was used. Sprague-Dawley rats were decapitated, blood collected and allowed to clot, and tissues homogenized in five volumes of buffer. Two ml of serum or tissue homogenate was added to dialysis tubing which was placed in 200 ml of phosphate buffer. ³H-PCP (added to the buffer) came to steady-state with serum or homogenates within 24 hours. ³H-PCP (10⁻⁶ to 10⁻⁹ M) had a greater affinity for tissue homogenates than for serum. At 10⁻⁷ M of ³H-PCP, the order of binding (pmoles ³H-PCP/mg protein) was brain (3.2), liver (2.9), lung (1.5) and serum (0.6). These data agree with the distribution data with the exception that PCP levels in lung and liver are higher than those in brain. Experiments were also carried out to determine if other drugs of abuse (morphine, nicotine, pentobarbital and diazepam) would compete with ³H-PCP binding to serum. The only compounds that displaced bound ³H-PCP were two of its metabolites and nicotine to a limited extent. (Supported by U.S.P.H.S. grant no. DA-02396).

IN VITRO STIMULATION OF CHONDROSARCOMA RNA SYNTHESIS BY BOVINE GROWTH HORMONE. M.E. Bembek* and J.P. Libertini*, Dept. of Biochem. Med. Col. of VA, Richmond, VA 23298.

Recent information suggests that the N-terminal region of the growth hormone (GH) molecule displays many of the metabolic actions associated with the native hormone (GH 1-191). A specific GH fragment, GH 96-133, termed AII, stimulates adipose and liver tissue metabolism. In the present study rat chondrosarcoma was used as the test system because cartilage is the most responsive tissue to GH in vivo. Chondrocytes were isolated from tumor mice after brief exposure to .2% collagenase at 37°. Preliminary studies showed that reproducible results were obtained using 1-2X10⁵ cells/ml + test substances in 1 ml modified culture medium at 37°. 1 µCi ³H-uridine was present for 2 h intervals prior to stopping the reaction. Radioactivity of acid-precipitates (³H-RNA) was determined in quadruplicate samples and quench corrected. Chondrocytes were exquisitely sensitive to AII; as little as 10⁻⁹ M fragment stimulated RNA synthesis (p<.01). Surprisingly GH (1-191) also enhanced RNA synthesis; 4X10⁻¹⁰ M stimulated 34% above control levels. These results indicate that mammalian chondrocytes may be a valuable in vitro system to investigate the metabolic actions of GH fragments with the aim of learning about structure:activity relationships.

HUMAN STRESS ANALYSIS FOR BIO-MEDICAL PROBLEMS AND PSYCHOSOMATIC MEDICINE. John C. Bartone, Michael P. Kradz, Brenda M. Reynolds* and Mary Rebecca Bartone*, The American Health Research Institute, Annandale, Virginia 22003.

The American Psychiatric Association, with its *Diagnostic and Statistical Manual of Mental Disorders (DSM-II (1968), DSM-III (1977))*, and the American Psychological Association with its Task Force on *Descriptive Behavioral Classification*, present discordant discontentance on the classification, understanding and treatment of the illnesses of mankind. While DSM-II is "the foremost classification system for emotional and behavioral disorders (Woody, 1980), the APA Task Force prefers a less disease-oriented model, as one of entire patient ecology. DSM-III changes are insufficient. Diagnoses of etiology are critical for both systems and hence the importance of nosology. Also at stake are idiographic versus nomothetic methods for clinical assessment of patients' complaints and disorders as well as attitudinal dispositions and care.

Both systems and all aspects of human illnesses and endeavors contain large reservoirs of *unidentified* stress of great complexity which creates expanding psychosomatic conditions and diseases, behavioral distortions and personality derangements.

A third system is proposed for stress analyses which dissects stress into rational compartments for clinical assessment, treatment and resolution. Stress can no longer be treated as a single entity. Its myriad specificities do ramify every life. Behavior and disease require its dissection.

EFFECT OF GOLD THIOLACTOSE TREATMENT ON THE MOUSE PANCREAS. G. R. Bryson, J. F. Jeffrey, and S. R. Webb. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284

Gold thioglucose (GTG) will preferentially destroy the cells of the ventromedial hypothalamus (VMH). This results in release of inhibition by the VMH - sympathetic system on insulin secretion from the beta (β) cells of the pancreas. Continued stimulation via the lateral hypothalamus (LA) - parasympathetic system can then occur and result in obesity, hyperinsulinemia and B cell proliferation.

Male mice of the strains C57BL/6J and SWR/J were given ip injections of GTG (1.6, 0.8, or 0.4 mg/g body wt.) to determine if the treatment would induce B cell proliferation and provide a greater B cell mass. C57BL/6J mice were resistant to the toxic and VMH effects of GTG treatment at all dosage levels. SWR/J mice, on the other hand, were more susceptible to its toxic effects with mortalities of 88%, 50% and 10% for doses of 1.6, 0.8 and 0.4 mg/g, respectively. VMH lesions were confirmed in obese SWR/J survivors. These mice had transient hyperglycemia and glucose intolerance. After glycemia and body weight had stabilized the pancreases were found to have larger islets due to an increase in B cells.

This technique represents one method of increasing the B cell mass of the pancreas for studies on isolated islets or their cultured B cells, but it is not expeditious, uniform between animal strains, or cost effective.

(Supported by NIH grant R01-AM21730)

A STUDY OF NUCLEUS RAPHE MAGNUS AFFERENTS IN THE RAT USING THE HORSEADISH PEROXIDASE TECHNIQUE AND TETRAMETHYLBENZIDINE NEUROHISTOCHEMISTRY. Susan M. Carlton*, Eric G. Young* and George R. Leichnetz*. Dept. of Anatomy, Med. Col. of Va. Va. Commonwealth Univ., Richmond, Va., 23298.

Since the nucleus raphe magnus (NRM) plays an important role in a descending pain-inhibiting system through its projections to the spinal trigeminal complex and spinal cord dorsal horn, defining its afferent systems became essential in order to identify other CNS nuclei which could potentially influence analgesic mechanisms by virtue of their connections with NRM. Accordingly, horseadish peroxidase (HRP) gel implants or fluid HRP injections were made within NRM and in adjacent areas (through previously implanted stainless steel cannulae) in 11 adult male albino rats. Those nuclei which were consistently labelled with retrogradely-transported HRP include the thalamic parafascicular nucleus (PR), zona incerta (ZI), dorsal and lateral periaqueductal gray (PAG), the deep layers of the superior colliculus (DSC), nucleus cuneiformis (NC), and a cell group in the ventral PAG which appears to be continuous with the nucleus of Darkschewitsch (ND). Control spinal cord HRP gel implants demonstrated that the ZI, DSC, and ND also project to the spinal cord, and thus the possible involvement of axons of passage originating from these nuclei and passing through NRM must be considered. However, the heavy and consistent labelling of the PR, PAG, and NC strongly suggests that these nuclei constitute part of the repertoire of NRM afferents.

BOVINE GROWTH HORMONE FRAGMENT 1-133: CHARACTERIZATION AND SOMATOMEDIN-LIKE ACTIVITY. L.A. Durham III* and J.P. Libertini*, Dept. of Biochemistry, MCV/VCU, Richmond, VA 23298.

The somatomedins (SMs) are a family of low mol. wt. peptides which are thought to mediate many biological actions of growth hormone (GH). In addition to other activities, the SMs stimulate *in vitro* sulfation and DNA synthesis of cartilage tissue. Little is known at the molecular level regarding the *in vivo* production of SM although it's clear that GH is involved in some way. Recent indirect evidence suggests that GH is cleaved endogenously to produce SM activity. To examine this possibility directly, GH was digested with thrombin for 30 h at 37°. The reaction products were reduced and carboxymethylated prior to separation by Sephadex gel filtration at room temperature. Two products were obtained and identified as GH (1-133) and GH (134-191) by SDS-gel electrophoresis and amino acid and N-terminal analyses. GH (1-133) at 10^{-10} M significantly stimulated ^{35}S uptake and ^{3}H -methylthymidine incorporation into DNA of hypox rat costal cartilage *in vitro*. GH (134-191) had slight activity which may be due to GH (1-133) contamination. Native GH (1-191) had little stimulatory activity. These data clearly show that SM activity can be derived from the native GH molecule which is devoid of such activity and suggest that *in vivo* production of SM activity may arise via specific proteolytic cleavage of the GH molecule.

CHARACTERIZATION OF PLASMA ZINC BINDING PROTEINS IN FAMILIAL HYPERZINCEMIA. M. L. Failla and M. van de Veerdonk*. Department of Biochemistry & Nutrition, Virginia Tech, Blacksburg, VA 24061.

In 1976 Smith and associates reported the presence of extremely high plasma concentrations of zinc in 5 of 7 members of one family and 2 of 3 second-generation individuals (Science 193, 496). Moreover, they demonstrated that familial hyperzincemia (HZ) was not due to toxic ingestion or contamination, nor was it associated with health problems. The present studies were undertaken to compare the distribution of plasma zinc in normal (N; $< 1.0 \mu\text{g Zn/ml}$) and HZ ($> 3 \mu\text{g Zn/ml}$) individuals. N and HZ plasma Zn quantitatively eluted from Sephadex G100 with molecular weight species $> 100,000$ (a 2 macroglobin) and 60-80,000 daltons. The additional complement of Zn in HZ plasma was present in the second peak. Potential zinc-binding entities of this size include albumin (Al), transferrin (Tf), and histidine-rich glycoprotein (HRG), and perhaps an uncharacterized protein in HZ individuals. That zinc was not associated with Tf was ascertained by affi-gel affinity chromatography. Anti-human IgG was bound to Protein A-Sepharose and peak II material applied. Zinc and Al were quantitatively bound to the antibody-containing matrix. These results demonstrate that additional quantity of zinc in HZ plasma is associated with one or more albumin-like species. The biochemical basis for enhanced binding is being investigated. (Supported by NIH AM 20420)

PRELIMINARY RESULTS IN DETECTION OF LEVELS OF PROTEIN NUTRITION BY SPECTROPHOTOMETRIC DIFFERENCES IN BLOOD PLASMA OF RATS. G. Colmano and S. S. Edwards, VPI & SU, College of Veterinary Medicine, Division of Veterinary Biology, Blacksburg, VA 24061

Preliminary analysis of absorption spectra scans of blood plasma on three levels of protein nutrition (4%, 15%, and 40% casein), comparing the absorbances of dipeptide bonds (190 nm), aromatic amino acid residues (278 nm), hemoproteins (414 nm) and the 452-578 nm difference for bilirubin), ceruloplasmin (278/610 nm), and oxidized ascorbic acid (630/278 nm), indicate that as long as the animals remain healthy the blood system is strongly homeostatic and is not basically changed in its protein composition, even by strong variations in levels of protein nutrition. A statistical analysis is in progress on the correlation of blood plasma absorption peaks of rats on three levels of protein nutrition, superimposed stress and added bacterial infections. Rats (corticosterone producers) and hamsters (cortisol producers) are under study for spectral absorbance changes, physiological changes, and pathological changes. The digitized spectra and other pertinent data are now being stored in a repository library for further computer analysis.

SPECTROPHOTOMETRIC ABSORBANCE DETECTION OF LOW LEVELS OF LEAD IN BLOOD PLASMA OF RATS. S. S. Edwards and G. Colmano, VPI & SU, College of Veterinary Medicine, Division of Veterinary Biology, Blacksburg, VA 24061

Absorption spectra scans of blood plasma from mice and quail with lead poisoning indicated differences in major absorption peaks of protein at 190nm (dipeptide bonds) and 278 nm (aromatic amino acid residues). In a preliminary experiment we established from absorption spectra of blood plasma some limits at which the lead in the diet affected the balance of proteins. We used 21 day old male rats and fed 2 animals 5ppm and 2 animals 10 ppm of lead in their feed. Three control animals were fed normal rat chow. The following table shows levels of lead consumed in 24 days compared with major absorption peaks found in blood plasma.

Days on Pb	No. of Animals	5 ppm Expt. g Pb $\times 10^{-6}$ ml ⁻¹ blood plasma	Major Absorption Peaks (nm)			Days on Pb	No. of Animals	10 ppm Expt. g Pb $\times 10^{-6}$ ml ⁻¹ blood plasma	Major Absorption Peaks (nm)		
			190	278	190/278				190	278	190/278
0	2		5086	52.70	96.51	2			5198	52.65	98.73
9	2	3.98	4718	51.40	91.79	2	8.25	4934	54.00	91.37	
18	2	6.24	5875	65.75	89.35	2	13.15	6278	74.05	84.78	
24	2	7.32	6263	75.50	82.95	2	14.91	6558	82.25	79.73	

ACUTE TOXICITY AND BEHAVIORAL ACTIVITY OF PHENYLCYCLODINE AND ITS PYROLYTIC PRODUCTS, PHENYLCYCLOHEXENE AND PIPERIDINE, IN MICE. A.S. Freeman* and B.R. Martin. Dept. of Pharmacol., Med. Col. of Va., Richmond, VA 23298.

Previously, we reported that phenylcycloidine (PCP) is partially pyrolyzed to phenylcyclohex-1-ene (PC) when it is smoked. The presence of piperidine in mainstream smoke has now been detected by 1) thin-layer chromatography of condensates generated from the smoke of (3H-piperidyl)-PCP-containing cigarettes and 2) gas chromatography-mass spectrometry of smoke condensates. The acute toxicities of PCP, PC and piperidine in mice were assessed by determining their LD50's following intravenous injection. The LD50's (umoles/kg, confidence limits) were 56 (53-61) for PCP, 576 (534-621) for piperidine and 447 (428-467) for PC. The effects of these compounds on motor coordination were assessed by the inverted screen test. The ED50's (umoles/kg, confidence limits) for inhibition of completion of the task were determined immediately following intravenous injection. PCP (4.1, 3-5.1) was most effective, followed by piperidine (221, 185-266) and PC (325, 294-360). The effects of piperidine and PC had disappeared within 5 min., whereas those of PCP lasted approximately 25 min. It is concluded that PC and piperidine contribute little to the acute lethal or incoordinating effects of smoked PCP. (Supported by U.S.P.H.S. grant no. DA-02396).

GLUCOSE-INDUCED INSULIN SECRETION FROM ISOLATED HAMSTER

ISLETS. M. Griffiss, P. F. Giebel, G. R. Bryson, and S. R. Webb. Dept. of Biology, VA. Commonwealth University, Richmond, VA 23284.

Stimulus-induced insulin secretion from the beta cells of pancreatic islets has traditionally been examined using intact animals or by perfusion of the functionally isolated pancreas. The development of methods to isolate physiologically viable islets has contributed to a renewed interest in factors that affect secretion by the islet cells which are removed from other influences of the animal.

Islets were isolated from the pancreases of Golden Syrian Hamsters and their response to stimulation with glucose was evaluated. Islets were isolated using established collagenase digestion and ficoll gradient techniques and were transferred (75-100/assay) to a perfusion chamber equipped with a 2.5 μ m filter; the islets were free of acinar tissue. Chambers were perfused at 0.6 mL/min with glucose at concentrations of 0, 2.5, 5.6, and 22.2mM. An immediate peak of insulin secretion occurred after sequential stimulation at each glucose concentration. After each peak insulin secretion was maintained at a level above the previous lower concentration. Upon return from 22.2mM to 0mM glucose there occurred an unexpected and large peak in insulin secretion. This preliminary study provides baseline data for studies on factors affecting hormone secretion by islets. (Supported by NIH Grant R01-M21730)

EFFECT OF TIME AND TEMPERATURE ON POST-MORTEM CHANGES IN CORNEAL EPITHELIAL GLYCOGEN LEVELS. T.M. Harris, E.R. Berry, and L.B. Sheppard*. Department of Anatomy, Medical College of Virginia, Richmond, Virginia 23298.

Glycogen levels in corneal epithelium are sensitive indicators of the corneal vitality and are related to the success rate of keratoplasty. Epithelial glycogen stores are quickly depleted in response to stress, anoxia and various storage conditions (Thoft & Friend, 1976).

Harris, Berry, and Sheppard (1981) reported a new technique for the study of corneal epithelial glycogen. The technique utilizes micro-electrophoresis in agarose gel and permits the quantitative analysis of the glycogen from approximately 1/4 of a single human cornea. Using this procedure the time-temperature kinetics of glycogen disappearance from rabbit corneal epithelial extract was studied. Glycogen disappeared at a rate of 54.9%/hr. at 10°C, 15%/hr. at 6.5°C and 5.7%/hr. at 5°C.

In recent preliminary studies it was shown that demonstrable glycogen levels are totally depleted from rat/it eyes left *in situ* after death at room temperature for four hours; a trace was present at three hours and approximately 50% was present after two hours. The results of other preliminary studies involving various storage conditions at different temperatures will be commented on briefly.

SHORT-TERM ALTERATIONS IN TRACE METAL STATUS IN THE

STREPTOZOTOCIN-DIABETIC RAT. R. F. Kiser* and M. L. Failla. Department of Biochemistry & Nutrition, Virginia Tech, Blacksburg, VA 24061.

Male Sprague-Dawley rats were injected ip with streptozotocin (STZ) to induce the diabetic condition. At 0, 1, 2, 4, 7, 14, 21 and 28 days, the level of Zn, Cu, Mn and Fe was quantitated in liver, kidney, duodenum and testes. Renal Zn and hepatic Mn content were significantly elevated in diabetic rat relative to controls by 2 days after STZ injection. Similarly, by 7 days the Zn content of liver and testes and Cu level of liver and kidney were significantly increased. The degree of accumulation of the metals in indicated tissues was proportional to the duration of the diabetic state. Elevated levels of hepatic and renal metallothionein, a soluble heavy metal binding protein, were also observed as early as 24-48 hours post-injection. Additional alterations in the cytosol distribution of Zn and Cu in liver and kidney were also found to be time-dependent. The potential role of short-term trace metal fluxes in the biochemical adaptations to the diabetic state, as well as the potential secondary complications resulting from heavy metal accumulation in insulin-dependent diabetes, will be discussed. (Supported by USDA Competitive Grant and J. L. Pratt Animal Nutrition Program)

THE MECHANISM OF ASBESTOS-INDUCED CARCINOGENESIS: CALCIUM AND PLASMA MEMBRANE INTEGRITY. J. H. Guth, Ph. D. Inter-science Research, Inc., 2614 Wyoming Ave., Norfolk, VA 23513

The major properties determining carcinogenic potential of asbestos fibers, are their size and shape. The chemical composition has minimal relevance. The initial cellular interaction is the partial or complete phagocytic uptake of fibers of appropriate sizes. Phagocytotically-active cell-types, such as macrophages, appear to be the most sensitive. The most carcinogenic fiber size is approximately 1.25 X 3.75 microns or longer. Cell impalement, where the fiber is not completely taken into the cell, or has penetrated the membrane mechanically, seems to be the initial damaging event. Within 36 hours after application of asbestos fibers, gross karyological abnormalities appear. Polyploidy and chromosome breakage have been observed which must lead to mutagenesis and ultimately, carcinogenesis. All of these results are predictable from what is known about the capabilities, compartmentation, and management of the calcium ion in mammalian cells. Allowing excess Ca^{++} to leak into the cytosol is known to (1) cause abnormal chromosomal condensation, (2) activate the mitotic spindle contraction and mitotic cleavage off-schedule, and (3) modulate the phosphorylation of histones, and thus gene readout. A leaky plasma membrane and a disturbance in Ca^{++} levels can bring together all major observations on asbestos carcinogenesis into a unified theory.

OPiate ANALGESIA TESTING IN RABBITS: EVIDENCE FOR THE RELEASE OF ENDOGENOUS OPIATES. Dennis E. Jones*, Agneta Ohlsson* and William L. Dewey. Dept. of Pharmacol., Med. Col. of Va., Richmond, VA 23298

Our previous data in mice have shown that the analgesic effect of exogenously administered morphine sulfate (MSO₄) may be mediated through release of endogenous opioid substances into the cerebrospinal fluid (CSF). In order to investigate this more fully, we developed an analgesic rabbit model which allowed withdrawal of sufficient quantities of CSF for assay of opioid activity. A cutaneous skin twitch assay was developed in which the spinal reflex mediated contraction of the cutaneous musculature in response to an external thermal stimulus was measured. A dose dependent inhibition of this response was seen following injection of MSO₄. CSF was withdrawn via cisternal spinal tap at the peak of analgesic activity. This CSF, added to the tissue bath of electrically stimulated guinea pig ileum (an opiate bioassay), was found to inhibit contractions in a dose dependent manner similar to the inhibition produced by opiates. This inhibition was reversible by naloxone. Such activity was absent in the CSF of saline treated rabbits. Experiments with radiolabeled morphine have shown that this inhibitory activity is not due to either morphine or its metabolites in the CSF. These experiments in rabbits confirm our previous results in mice. (Supported by U.S.P.H.S. Grant #DA-01647).

VASCULAR RESPONSIVENESS OF THE PREGNANT RAT TO ANGIOTENSIN

II. M.E. LaVecchia* and J.L. Hart Biology Dept. George Mason University, Fairfax, VA. 22030

Systemic arterial blood pressure (BP) responses of pentobarbital anesthetized non-pregnant (estrus) (NP) rats and rats at 3 stages of pregnancy (7-8, 11-13, 18-19 days) to angiotensin II (AII) (32, 320, 640 ng/kg/injections were recorded. Dose-related increases in BP occurred in all groups; however analysis of variance indicated that the pressor responses to AII were significantly less ($p < .05$) in late pregnant rats than in NP rats. This confirms previous reports of decreased pressor responses to AII during pregnancy.

In order to determine if decreased blood vessel responsiveness plays a role in the diminished pressor activity of AII in the intact rat, isolated aortic strips and femoral artery cylinders from NP and late pregnant (P) rats were studied. Isometric tension of these vessels was recorded while they were in 37°C oxygenated Krebs-filled tissue baths. After 90 min equilibration, cumulative dose-response curves to AII (3×10^{-12} , 3×10^{-8} , 3×10^{-6} M) were done. Tension development of aortic strips from P rats was significantly greater than that from NP rats. Maximum tension of femoral arteries from P and NP was not different. These results do not support the hypothesis that decreased blood vessel responsiveness contributes to the diminished pressor activity of AII in the pregnant intact rat. (Supported by GMU CRAS Grant # 2-100035)

GLYCOGEN CHANGES IN MUSCLE TRANSPLANTS AFTER VARIOUS TREATMENTS. F.S.F. Mong, and J.L. Poland, Depts. of Anatomy and Physiology, Med. Coll. Va., Richmond, Va. 23298.

Since free muscle transplantation has been successful in animals and in humans, it is important to understand some basic properties before further clinical application is undertaken. The present study compared glycogen changes in transplanted and normal muscles following exercise or fasting. Male Sprague-Dawley rats (120 gm. wt.) were used. The extensor digitorum longus (EDL) and soleus (SOL) muscles were removed, switched to each other's muscle bed and sutured to the tendon stumps left *in situ* (thus, the EDL muscle became the SOL-transplant, and vice versa). Fifty days later, half of the rats ran for 30 mins (1 mph) on a treadmill (having been trained previously for 1 week) and were sacrificed either immediately or 4 hrs after the exercise. The other half of the rats were fasted for 48 hrs and then sacrificed either at the end of the fasting period or after being refed for 4 hrs. Glycogen levels were determined in the EDL-transplants, SOL-transplants, and contralateral EDL & SOL muscles from these experimental and control rats. Glycogen concentration in the transplants decreased 30 to 60% as did the glycogen of contralateral normal muscle either immediately after exercise or after 48 hrs of fasting. Glycogen repletion after either exercise or with refeeding was similar yet more complete in normal muscle than in transplants after 4 hrs. It is concluded that with exercise or fasting glycogen in transplants changes in a similar manner to that in normal muscle. (Supported by Muscular Dystrophy Assoc. & MCV Grant-in-Aid).

INTESTINAL ABSORPTION OF COPPER AND ZINC IN THE STREPTOZOTOCIN-DIABETIC (STZ) RAT. S. P. Osborne* and M. L. Failla. Department of Biochemistry & Nutrition, Virginia Tech, Blacksburg, Va. 24061.

We have recently found significantly elevated levels of Cu and Zn in livers and kidneys of STZ rats. These alterations in tissue trace metal levels were shown to be due to the hormonal imbalance characterizing the diabetic condition. The present studies were undertaken to determine if the increased complement of tissue Cu and Zn was due in part to increased intestinal absorption of these metals. Control and STZ rats were administered either ^{64}Cu or ^{65}Zn by stomach tube, given free access to chow and water and sacrificed at 22 hr. STZ rats absorbed 35 and 66% of the ^{64}Cu and ^{65}Zn , respectively. Controls absorbed 28% ^{64}Cu and 61% ^{65}Zn doses. Since STZ rats (2 weeks after injection) consume twice as much diet/day/kg body wt as controls, the results suggested that STZ rats were absorbing twice as much dietary Cu and Zn as controls. This was confirmed by feeding ^{64}Cu and ^{65}Zn -labeled purified diets. These data, as well as the quantity of metallothionein in intestinal mucosa in control and STZ rats, suggest that homeostatic control of Cu and Zn absorption is impaired in the STZ-diabetic rat. (Supported by USDA Competitive Grants and J. L. Pratt Animal Nutrition Programs).

COMPUTER SIMULATION OF A PROPOSED MODEL OF CALCIUM UPTAKE IN SARCOPLASMIC RETICULUM. S. Rapundalo* and J. Feher*, Dept. of Physiology, Med. College of Va., Richmond, Va. 23298.

Several reaction schemes have been proposed to explain the coupling of calcium (Ca) transport with ATP hydrolysis in skeletal sarcoplasmic reticulum (SR). We attempted to evaluate a specific reaction scheme (a Ca-ADP-Ca order of release) by using the electronic simulation program SPICE2. Previous attempts at simulating these schemes have suffered from either a lack of flexibility or difficulty in their mathematical formulation. The reaction scheme we evaluated explained some transient- and steady-state behavior of intact SR. The amounts of Ca translocated during the transient state reached 6-8 nmol/mg SR protein. Liberation of P_i exhibited an initial lag phase, which coincided with the rapid increase in total phosphoenzyme formation. Simulations show that the initial burst of Ca uptake corresponds to Ca desorbed from the enzyme. However, addition of EGTA-ADP did not have much effect on transient-state kinetics suggesting a qualitative error in the scheme. Steady-state uptake of Ca reached 104 nmol/mg protein in 1.5 min. Passive Ca efflux was accurately predicted by the simulation. However, the reaction scheme we evaluated lacks the correct Ca dependency. We were able to simulate ionophore-induced Ca release and obtained a concomitant rise in ATPase rate. Using simple network simulation techniques we have, for the first time, been able to evaluate transient- and steady-state behavior for a defined reaction scheme having a Ca-ADP-Ca order of release.

GLYCOSYLATED HEMOGLOBIN (HbA1) LEVELS IN MICE RECOVERING FROM EXPERIMENTAL DIABETES AFTER PANCREATIC ISLET TRANSPLANTATION. K. M. Morrison* and R. C. Kramp, Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Glycosylated hemoglobin (HbA1) is a modified hemoglobin molecule in which glucose becomes attached to the β chains. Normally present in blood cells in small quantities (6-8%), it becomes elevated 2- to 3-fold in diabetics. Since the glycosylation is a slow, nonenzymatic process, high plasma glucose of diabetics results in elevated HbA1. Assays for HbA1 are becoming clinically accepted as an objective, quantitative index of plasma glucose control in diabetics. Our study showed that streptozotocin diabetic mice recovered from hyperglycemia after isogeneic, subcutaneous transplantation of duct-ligated pancreas, but still showed impaired tolerance to an oral glucose load (3.0g/kg mouse). However, HbA1 levels in diabetic mice (4.09 \pm 0.23%) returned to normal (2.84 \pm 0.05% vs 2.57 \pm 0.05% in normals) within 9 weeks after transplantation or 3 weeks after recovery from hyperglycemia. Thus, transplant recipients maintain normal glucose homeostasis under normal feeding conditions.

CORRELATION BETWEEN NICOTINE BRAIN LEVELS AND BEHAVIORAL ACTIVITY IN RATS. L. Palmer*, H. L. Tripathi*, R. Brosius*, M. D. Aceto* and B. R. Martin. Dept. of Pharmacol., Med. Coll. of Va., Richmond, Va. 23298.

When nicotine (1 mg/kg) is injected s.c. into male Sprague-Dawley rats, it produces maximum antinociception (tail-flip response) at 2 min. and only 10% antinociception at 10 min. Rats were also injected s.c. with ^3H -nicotine (1 mg/kg) so that the time-course of ^3H -nicotine in brain and plasma could be determined. Maximum brain and plasma levels (mean \pm S.E.) occurred at 10 min. (1.24 \pm .06 ng/mg) and 0.27 \pm .07 ng/ μl , respectively) and fell gradually over the next 50 min. Lack of correlation between antinociception and brain levels of nicotine led to the investigation of other central effects of nicotine. Rats treated with nicotine (1.5 mg/kg, s.c.) were tested in an open field for spontaneous activity and on a rotarod for motor coordination. Maximum effect in both tests (90% and 48% of control, respectively) occurred at 10 min. and returned to control levels within 60 min. for spontaneous activity and 35 min. for rotarod activity. The brain levels of nicotine correlate well with nicotine's effects on spontaneous activity and motor coordination but not with its antinociceptive effects. The short time course of antinociceptive action may be due to a rapid development of tachyphylaxis which is not seen with the other effects of nicotine. (Supported by U.S.P.H.S. grant no. DA-02384).

VITAMIN A, ZINC, AND RETINOL-BINDING PROTEIN IN BURN PATIENTS. M. Riggler*, R.B. Brandt and W. Chan. Department of Biochemistry, Medical College of Va., Richmond, Va. 23298.

Vitamin A is essential for normal growth, vision, and reproduction. It is also important in epithelial maintenance and differentiation and in providing immunity from infection. Following trauma, plasma levels of vitamin A decrease. In view of the widespread role of vitamin A in multiple biochemical processes it is important to determine the interrelationships between vitamin A and the components involved in its transport in trauma states. This study examined the effect of burns in humans on plasma levels of vitamin A, its carrier protein, retinol-binding protein (RBP), albumin, total protein, and zinc.

Plasma vitamin A levels decreased 29%-77% as a function of the severity of the burn. Zinc and RBP levels also decreased 17%-42% and 38%-60%, respectively. The level of total protein however remained normal. This suggests that the decrease in the carrier protein is a selective one. The data supports the hypothesis that vitamin A levels decrease due to impaired mobilization from the liver and is also constant with zinc acting as a regulatory factor in the synthesis or activation of the transport protein. (Supported by funds from NECR)

EFFECTS OF POLYCHLORINATED BIPHENYLS ON SYNAPTOSOMAL AND MITOCHONDRIAL ATPASES FROM MOUSE BRAIN. D.L. Rostin* and B.R. Martin, Dept. of Pharmacology, Med. Col. of Va., Richmond, VA. 23298

We have previously reported that polychlorinated biphenyls (PCBs) alter central neurotransmitter function *in vitro* at concentrations of 10^{-6} to 10^{-4} M. In the present studies the activity of ATPases from isolated mouse brain synaptosomes and mitochondria was evaluated by means of a coupled-enzyme ATP-regeneration system. A linear relationship between enzyme concentration and rate of ATP hydrolysis was demonstrated. Ouabain, a specific Na^+/K^+ -ATPase inhibitor, produced maximal inhibition at a concentration of 1 mM. The mitochondrial Mg^{2+} -ATPase inhibitor, oligomycin, inhibited activity maximally at 10^{-7} M. Addition of PCBs (Aroclor 1254) to these systems *in vitro* inhibited both synaptosomal (Na^+/K^+ - and Mg^{2+} -ATPases) and mitochondrial (oligomycin-sensitive and insensitive ATPases) enzyme activity with IC50 values for PCBs of approximately 10^{-4} and 5×10^{-6} M, respectively. Varying the time of incubation of enzyme with 10^{-5} M PCBs (1, 2, 5, 10, 15, 30 and 60 min.) produced little change in degree of inhibition. In addition, ATPase activity was not altered in mitochondria and synaptosomes isolated from mice 45 min. following oral administration of PCBs at 50, 100, 250 or 500 mg/kg. These *in vitro* inhibitory effects on neuronal ATPases are consistent with our previous findings that PCBs enhance neurotransmitter release. (Supported by NIH Training Grant 5-T32-ES07087-03).

ULTRASTRUCTURE OF BLOOD VESSELS GROWING WITHOUT MITOSIS INTO IRRADIATED CORNEAS. M.M. Shelley*, J.D. Wilson*, H.R. Seibel, and J.L. Montour*. Depts. of Anatomy and Radiology, Med. Col. of Va., Richmond, VA. 23298.

Our previous studies of neovascularization in irradiated corneas revealed that substantial early formation of new vessels occurs despite severe inhibition of endothelial cellular proliferation. We have now performed ultrastructural studies to elucidate the cellular mechanisms permitting persistent neovascularization. The left eyes of rats were irradiated with 1000, 2000 and 8000 rads of 45 kVp X-rays. Then both corneas were cauterized with AgNO_3 to induce vascular ingrowth. Corneas were fixed by perfusion at 2 and 4 days. At 2 days, sprouts projected from limbal vessels into control and irradiated corneas. In controls, mitoses were sometimes seen in endothelial cells (EC) at the tips of sprouts and in less advanced EC; no mitoses were observed after irradiation. In control and irradiated corneas, EC were hypertrophic and contained abundant rough ER and free ribosomes. Similar EC hypertrophy and increased organelles were present at 4 days. Also, the orientation of many EC suggested migratory activity. Numerous EC had pseudopods extending toward the lesion; and the vascular wall was often 2 or 3 cells thick near the tips of sprouts, with luminal extensions between overlapping EC. In irradiated corneas some EC contained several small nuclei, perhaps indicating abortive mitosis. Thus, it appears that EC hypertrophy and migration can operate without mitosis to yield considerable early vascular growth. (Aided by NIH Grant CA-28436).

THE IDENTIFICATION OF A NEW PHENCYCLIDINE ANALOG, 1-(1-PHENYLCYCLOHEXYL)-4-METHYLPYPERIDINE, AS A DRUG OF ABUSE. W. H. Soine*, R. L. Balger*, K. E. Berglund*, C. D.

Wafford*, and D. T. Ageles*. Dept. of Pharmaceutical Chemistry, 2nd Dept. of Pharmacology, Med. Coll. of Va., and Drug Examination Section, Bureau of Forensic Science, Dept. General Services, Richmond, VA. 23298.

A previously unreported phencyclidine (PCP) analog, 1-(1-phenylcyclohexyl)-4-methylpyperidine (I), in which the piperidine ring has been substituted with 4-methylpyperidine, has been observed to be an abused drug in Virginia. I was obtained coated over parsley in an approximate concentration of 1.7% (w/w). I-HCl was isolated, purified and compared to authentic I-HCl (sample obtained from DEA and synthesized in the laboratory) using melting point, IR, $^1\text{H-NMR}$, GC and GC/MS. Unequivocal identification of I-HCl was based on its $^{13}\text{C-NMR}$. The intraperitoneal LD_{50} of I-HCl in male mice was 301.1 $\mu\text{moles/kg}$ (267.1-339.3, 95% confidence limits) and the ED_{50} was 45.0 $\mu\text{moles/kg}$ (37.2-54.2). The therapeutic index, $\text{LD}_{50}/\text{ED}_{50}$, for I-HCl was 6.7 and is much lower than that observed with phencyclidine, 38.1. Two additional nitrogen containing compounds were isolated and identified using only GC/MS. These contaminants were phencyclidine and N-cyclohexyl-4-methylpyperidine, and were present in extremely low concentrations. (Aided by NIDA grant DA-01442 and -07027)

METALLOTHIONEIN IN LIVER PARENCHYMAL AND NON-PARENCHYMAL CELLS: QUANTITATION AND POSSIBLE PHYSIOLOGICAL ROLES. C. V. Scorrington*, B. Bullis* and M. L. Failla. Department of Biochemistry and Nutrition, Virginia Tech, Blacksburg, VA 24061.

Metallothionein (MT), a low molecular weight, intracellular heavy-metal binding protein, has been shown to be elevated in liver of rats (1) injected with zinc or cadmium salts, (2) treated with endotoxin and (3) exposed to environmental stresses. The presence and role of MT in various liver cell types has not been previously studied. Liver parenchymal cells (PC) were isolated by differential centrifugation following perfusion with collagenase. Nonparenchymal cells (NPC) were isolated by a gentle, non-digestive, gravimetric separation technique that yielded 95-98% viable cells with < 0.2% parenchymal cell contamination. MT levels in PC and NPC cytosol were quantitatively determined by competitive ^{203}Hg binding assay followed by gel filtration chromatography. Both PC and NPC synthesize MT, although the basal level per mg cytosol protein is greater in the former than the latter. Administration of Zn and Cd salts significantly elevated the MT level in both cell populations. However, fasting only resulted in induction of PC MT biosynthesis. (Supported by NIH AM 363941).

A COMPARISON OF THE EFFECTS OF DIANABOL AND METHYLTESTOSTERONE ON MUSCLE CONTRACTION AND FATIGUE. S. Smith*, J. H. Richardson. Dept. of Biology, Old Dominion Univ., Norfolk, VA. 23508

The purpose of this study was to determine whether or not Dianabol (methandrostenolone), an anabolic steroid, was effective in increasing muscular strength and stamina. Studies done in the past have not provided accurate results, due to their research techniques. The technique in this study is highly accurate for measuring muscle strength and stamina. Thirty white rats were used. Ten served as control animals. Ten were given a daily dose of .35 mg/kg/day of Dianabol for 30 days. The remaining ten received a daily dose of .35 mg/kg/day of methyltestosterone. Strength of contraction of the muscle and fatigue time were measured on the physiograph. Results indicate that contraction strength and contraction time for the Dianabol group were not significantly longer than for control animals. However, the testosterone animals showed significantly stronger contractions and increased stamina over the other two groups. This study suggests that Dianabol does not increase strength or stamina.

PREFERENTIAL BINDING OF CHLORDECON (CD) BY PROTEINS AND HDL IN PLASMA. P. J. Soine*, R. V. Blanke, (Dept. Pathol.) and P. S. Gueglian, C. C. Schwartz (Dept. Med.), (Med. Coll. Va., Richmond, VA. 23298)

Preferential distribution of the pesticide, CD, to liver rather than to fat tissues in man suggests that this relatively nonpolar pesticide may be transported in plasma in a manner different from other organochlorine pesticides. Plasma binding of ^{14}C -CD was investigated *in vitro*, in human, rat and pig plasma and *in vivo* in rat plasma. In human plasma, the distribution of CD among proteins, HDL, LDL and VLDL was 46%, 30%, 20% and 6% when separated by serial ultracentrifugation. The distribution of cholesterol in the same plasma fractions was 4%, 20%, 63% and 7%. In pig and rat the order of binding was similar to man with CD binding to protein > HDL > LDL > VLDL. Separation of CD plasma fractions by Sep-Mn ppt and agarose gel electrophoresis (AGE) confirmed the results obtained by ultracentrifugation. The distribution of CD in rat lipoproteins was similar whether the CD was administered *in vivo* or incubated with plasma *in vitro*, with 80%, 11% and 9% bound to HDL, LDL and VLDL in either case. AGE of plasma bound CD showed that albumin was the major component of the protein fraction responsible for CD binding. Preferential binding of CD by albumin and HDL may explain its unusual tissue distribution when compared to other organochlorine pesticides such as aldrin and dieldrin which bind preferentially to VLDL and LDL and distribute preferentially to fat tissues. (Supported by USPHS AM29520 and NIEHS R01ES01519 grants.)

<p>MORPHOLOGICAL AND PEROXIDASE CHARACTERISTICS OF ANTIGENICALLY DISTINCT IMMATURE AND MATURE MACROPHAGES. A.K. Szakal, J.R. Yannelli*, Department of Anatomy, Medical College of Virginia, Richmond, Virginia 23298.</p> <p>Thioglycollate elicited Balb/c peritoneal macrophages (MP) were studied in vitro using macrophage-specific antiserum in conjunction with [Flab']₂ conjugates (FITC and ferritin) and peroxidase (PO) cytochemistry to identify immature and mature MP's. In 24 hr and 96 hr MP cultures 100% of the cells fluoresced after incubation with anti-¹²⁵I-macrophage serum (APMS-24) and FITC conjugate. After absorption of APMS-24 with mature MP's from 96 or 120 hr cultures, 58±14 percent of the cells in 24 hr cultures and only 1-2% of the cells in 120 hr cultures fluoresced. This paralleled the reduction in the number of P+ cells in cultures between 24 hrs and 120 hrs (56±2% to 1.3±0.6%). When 24 hr cultures were incubated with mature MP absorbed APMS-24 and ferritin conjugate and treated subsequently for PO activity the cells with PO reactivity in granules had ferritin labeled plasma membranes. The density of ferritin on the plasma membranes decreased as the number of P+ secondary lysosomes decreased with maturation. MP from 96-120 hr cultures treated similarly had no ferritin label, were PO- and contained numerous secondary lysosomes. The antigens on ferritin labeled immature cells with P+ granules, consistent with current classifications based on PO reactivity, were designated exudate macrophage surface antigens (EMSA). (Supported by MCV/VCU Grant-in-Aid).</p>	<p>PHENOTYPIC VARIATION AND OCULOCUTANEOUS INVOLVEMENT IN A RURAL VIRGINIA KINDRED WITH X-LINKED OCULAR ALBINISM. K.A. Szymanski*, J.A. Boughman*, R.S. Weinberg*, D.L. Olansky*, and W.E. Nance*. Dept. of Human Genetics, Med. Col. of Va., Richmond, Va. 23298</p> <p>X-linked ocular albinism is a rare genetic eye disease characterized by impaired visual acuity, photophobia, nystagmus, and decreased retinal pigment. A large rural Virginia kindred previously diagnosed with congenital nystagmus is presented which includes 287 individuals with 31 males reported to be affected. Ophthalmologic exams were consistent with the Nettleship-Falls type of X-linked ocular albinism showing albinotic fundi, macular hypoplasia and decreased acuities in affected males, and variable fundus pigmentation but normal acuities in carrier females. Severity of nystagmus was variable among affected males and was correlated to the amount of retinal pigment. Linkage analysis did not show the expected linkage with the Xp blood group. Cutaneous involvement has previously been demonstrated by the presence of macromelanosomes in both affected males and carrier females. Since disease expression is so variable, use of skin biopsies may be a useful adjunct in diagnosis of at-risk females. To test this, skin biopsies on 6 individuals were interpreted without knowledge of the clinical phenotype. The cutaneous melanosome abnormality was demonstrable indicating that routine light microscopic confirmation of carrier status in females is feasible and can be useful for the evaluation and counseling of at-risk individuals in families with X-linked ocular albinism.</p>
<p>TWINNING IN VIRGINIA: WHY IS IT DECLINING? M. Mosteller*, J. I. Townsend, L. A. Corey*, and W. E. Nance*. Dept. of Human Genetics, Med. Col. of Va., Va. Commonwealth Univ., Richmond, VA 23298</p> <p>Studies of secular trends in twinning rates show that the rates have been declining during this century in many nations around the world. More detailed analyses commonly reveal that the decline in overall rates is due to the dizygotic twinning rates; the monozygotic rates remain unchanged. In most nations the decline in dizygotic rates cannot be explained even after adjustment for maternal age and parity, known co-variables. Twinning rates for Virginia were calculated for comparison with the rates of other localities and investigation of possible causes for secular decline. Twinning rates declined by approximately 30% from 1918 to 1977 in Virginia. Twinning rates for selected years from 1938 to 1977 showed that, as elsewhere, dizygotic rates fell while monozygotic rates remained steady. Regression techniques showed that the decline was fully attributable to changes in maternal age and parity. Significant fluctuations in the annual twinning rates could not, however, be similarly explained. A fall in twinning rates at the beginning of the Depression and World War II suggested that emotional stress may play a role in secular changes in twinning rates. Emotional stress can lower the probability of physiological events essential to the formation of a dizygotic twin pair. Perhaps emotional stress has contributed to the decline in twinning rates around the world.</p>	<p>NICOTINE-INDUCED CHANGES IN BLOOD PRESSURE, HEART RATE RESPIRATION AND ANTINICOTINIC ACTION AFTER INTRACUTANEOUS INJECTION INTO RATS. H.L. Tripathi*, T.C. Fu*, M.D. Aceto* and B.R. Martin. Dept. of Pharmacology, Med. Col. of Va., Richmond, VA 23298.</p> <p>The purpose of the present investigation was to determine whether or not nicotine produced antinicotinic action after intracerebroventricular (I.C.V.) injections and whether or not antinicotinic was related to other nicotine effects. Nicotine (75 µg in 10 µl) was administered I.C.V. in male Sprague-Dawley rats (N=4) anesthetized with pentobarbital. Antinicotinic was measured by the tail-flick latency and blood pressure, heart rate and respiration were recorded at 0.5, 1, 2.5, 10 and 20 mins. Nicotine caused maximum reduction in blood pressure (37%) and heart rate (17%) at 1 min. which returned to normal by 2 and 20 min., respectively. Respiration increased 22% at 0.5 min. but was normal by 2 min. Maximum antinicotinic action (157%) was achieved at 2 min. and then declined gradually to 15% by 15 min. These results show that nicotine antinicotinic occurred independently of other nicotine effects. We also studied the distribution of 3H-nicotine (75 µg, I.C.V.) in brain areas, plasma and spinal cord. In brain, higher concentration of nicotine were found in hypothalamus, hippocampus, striatum and midbrain than in cerebellum, medulla and cortex. Nicotine readily penetrated the blood-brain barrier and appeared in the periphery. It remains to be established whether nicotine antinicotinic is totally central. (Supported by DA-02384).</p>
<p>D- AND L-LACTATE CATABOLISM IN TISSUES. M.G. Waters*, M.J. Rispler*, E.S. Kline and R.B. Brandt. Dept. of Biochemistry, Medical College of Virginia, VCU, Richmond, Virginia 23298</p> <p>Lactic acid metabolism is important physiologically for production of cellular energy, maintenance of blood glucose levels, storage of carbohydrates, and maintenance of acid-base balance. These functions have been associated with the L-(+) enantiomorph of lactate from glycolysis. The "unnatural" isomer, D-(-)-lactate, is formed in the catabolism of the 3-carbon growth inhibitor, methylglyoxal, by the glyoxalase enzyme and is found in measurable quantities in blood. In our study of the glyoxalase enzyme system, we became interested in determining the metabolic fate of D-(-)-lactate. Specifically, we wanted to compare the rates of oxidative catabolism of D- and L-lactate in various mammalian tissues. Uniformly labeled (U-¹⁴C) D- or L-lactate was incubated at 37° in a closed system with tissue homogenates in Krebs-Ringer phosphate buffer. Evolved ¹⁴CO₂ was trapped in a center well containing a fluted filter paper saturated with strong base and the radioactivity was determined. The rat tissues in which the D isomer is oxidized most rapidly are the heart, kidney, brain and liver. In liver and heart, the rate of oxidation of D-lactate exceeds that of L-lactate. The ratio of L-lactate to D-lactate oxidation is greatest in brain, followed by kidney, heart and liver. These results indicate that the rate of D-lactate catabolism is considerably greater than has been reported previously. (Supported by funds from the National Foundation for Cancer Research)</p>	<p>STIMULATION OF PROTEOGLYCAN SULFATION IN ISOLATED CHONDROSARCOMA CELLS BY INSULIN. D.H. Willis, Jr., and J.P. Libertini* Dept. of Biochemistry, Med. Col. of Va., Richmond, VA 23298.</p> <p>Mammalian cartilage responds to several growth promoting hormones. Owing to the difficulty of cartilage isolation and its tenacity, little more than descriptive information of these responses is available. Rat chondrosarcoma (CS) offers advantages over normal cartilage because larger amounts of tissue (>40 g) are readily obtained and easier to manipulate. Isolated cells were prepared from tumor minces by treatment with 0.2% collagenase at 37° for 20 min. Cells were washed, suspended in a modified culture medium and incubated ± test substances at 37°. After the appropriate labeling and incubation times, acid-precipitable radioactivity was measured. Continuous and pulse labeling experiments with ³⁵SO₄ (100 Ci/ml) demonstrated that a 6-8 h pulse gave optimal stimulation with both normal human serum (NHS) and insulin. Concentration curves from 0.6-5 X 10⁵ cells/ml showed that maximal stimulation occurred from 1-2 X 10⁵ cells/ml. Stimulation of proteoglycan sulfation by both insulin (0.7nM-181 nM) and NHS (0.5-15%) was concentration dependent. 36nM insulin gave maximal stimulation 31% above control (P<.01) while 16% stimulation was observed as low as 0.7-1.8 nM (P<.05). 5% NHS stimulated 47% above control (P<.01). These results represent the first demonstration that freshly isolated CS chondrocytes respond reproducibly to insulin. Experiments are planned to study the mechanism of action of insulin at the molecular level.</p>

AGING AND THE INFLAMMATORY RESPONSE OF MICE TO THIOLYCOLLATE. J.R. Yannelli and A.K. Szakal, Department of Anatomy, Medical College of Virginia, Richmond, Virginia 23298.

Experiments were designed to study the peritoneal cell response of 6 wk., 33 wk., and 73 wk. old C57BL/6J female mice to the inflammatory agent thioglycollate. Thioglycollate was injected i.p. (1 %/5 gm body weight). The PE cells were harvested by lavage with cold DMEM at 24 hr. intervals for 7 days. The cells were counted and characterized by nuclear morphology, peroxidase and nonspecific esterase reactivity. The resident population of cells in the age groups studied were composed of predominantly lymphocytes and a lesser number of macrophages ($20.5 \pm 2\%$ in 6 wk., and $13 \pm 2\%$ in 73 wk old animals). After the i.p. injection of thioglycollate there was an influx of peroxidase positive neutrophils and monocytes in addition to lymphocytes into the peritoneal cavity. The influx of peroxidase positive cells appeared to cease between 48 and 72 hours. The cellular composition of the peritoneal exudates changed with age. There was an increase in total cell number, however the fraction of peroxidase positive and nonspecific esterase positive cells decreased with age. This decrease is interpreted as a possible cause in the age-related decline in immunocompetence and wound healing.

Microbiology

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

HETEROCYST PIGMENTATION IN THE SYMBIOTIC CYANOBACTERIUM *ANABAENA AZOLLAE*. H. Azrolan*, R. Fisher*, and J. Gates.

Dept. of Biology, Va. Comm. Univ., Richmond, VA 23284

The *Azolla-anabaena azollae* association is the subject of much interest because it is an efficient nitrogen-fixing system. The site of nitrogen-fixation is localized in specialized cells of the cyanobacteria called heterocysts.

Mature heterocysts of free-living *Anabaena* do not fluoresce under the fluorescent microscope; whereas, mature heterocysts of the cyanobacteria micromanipulated from the fern leaf cavity do fluoresce. The quality and level of this fluorescence is dependent upon the age of the leaf from which the algal samples are taken. Heterocysts were isolated by the methods of Peterson (Plant Physiol. 61:688, 1978) and were subsequently extracted by freeze-thaw methods. Spectrofluorometric analysis of the cell-free extracts of these heterocysts demonstrate that phycocyanin (PC) is present. PC normally exists as an accessory pigment to PSII. Since there is no PSII activity in the heterocysts of cyanobacteria, the PC may be involved in transferring energy to PSI in heterocysts of the symbiotic cyanobacteria. Supported by USDA 5901-0410-9-0304-0.

RESPONSIVENESS OF T LYMPHOCYTE SUBSETS TO MACROPHAGE-DERIVED FACTORS. S.P. Black, K.D. Elgert, and J.M. Conroy. Dept. of Biology, Microbiol. Sect., Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061

The mixed lymphocyte reaction (MLR) was used to examine the response of normal and tumor-bearing host (TBH) murine T lymphocyte subpopulations in the presence of normal and TBH macrophage (Mφ) factors. Rapidly proliferating normal Lyt 1⁺ cells were enhanced beyond the level of unfractionated T cells by both normal and TBH Mφ supernatants. TBH Lyt 1⁺ cells were enhanced by normal Mφ supernatants but TBH Mφ supernatants inhibited the response. Slowly proliferating normal Lyt 2⁺ cells were restored to control levels by normal Mφ supernatants but TBH Mφ supernatants failed to restore the response. TBH Lyt 2⁺ cells were inhibited by normal Mφ supernatants, and although the inhibition by TBH Mφ supernatants was titratable, higher dilutions did not restore the response. Thus, TBH Mφ supernatants are altered from normal Mφ supernatants and TBH Lyt 2⁺ cells are altered in their ability to be augmented by Mφ-derived factors. These data shed some light on the mechanisms of tumor-induced immune debilitation. (Aided by a Whitehall Foundation Grant, by NIH Grant CA 25943, and by a Sigma Xi Scientific Research Society Grant-in-Aid of Research.)

DIFFERENCES IN SURFACE ANTIGENICITY OF THE N-FIXING PHYCOBIONTS OF DIFFERENT SPECIES OF THE *AZOLLA* FERN. D. Brown*, J. Gates, and R. Fisher*. Dept. of Biology, Va. Comm. Univ., Richmond, VA 23284

The cyanobacteria in the *Azolla* fern are named *Anabaena azollae*; however, little evidence supports the hypothesis that all species of *Azolla* associate with the same phycobiont. Antisera were prepared against cyanobacteria freshly extracted from the leaf cavities of *Azolla pinnata*, *A. caroliniana*, and *A. microphylla* and used in adsorption and cross-reaction studies using fluorescent antibody staining. Initially all 3 phycobionts reacted strongly with all 3 antisera, and only after extensive adsorption could differences be detected. *A. pinnata* phycobiont appears to have antigens not present on the surfaces of the other 2 species. The phycobionts from *A. caroliniana* and *A. microphylla* appear to have antigens not present on the *A. pinnata* phycobiont. Since *A. pinnata* is in the Subgenus *Rhizosperma* and the others are in the Subgenus *Buazolla*, these slight differences in surface antigenicity follow the phylogeny of the fern. Supported by USDA 5901-0410-9-0304-0.

CHARACTERIZATION OF THE BOVINE PARVOVIRUS GENOME. P. R. Burd, R. C. Bates, and E. R. Stout. Dept. of Biology, Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061.

A restriction map was prepared for the bovine parvovirus (BPV). Isolated single-stranded viral DNA was radio-labeled by incorporation of [α -³²P]-dNTP's using bacterial and viral DNA polymerases at positions representing the 3' or 5' termini of the viral DNA or at positions internal to the termini. Specifically radiolabeled viral DNAs were digested with various restriction enzymes and separated by agarose or polyacrylamide gel electrophoresis. Sizes of viral DNA fragments were determined by comparison to separated restriction fragments of M13 RF DNA. The fragment order was determined by incomplete digestion of specifically labeled viral DNAs. The order of fragments was determined for nine enzymes (Bam I, Bgl I, Bgl II, BstE II, EcoR I, Hinc II, Hpa I, Kpn I and Pst I). For these enzymes most of the cleavage sites were located near the ends. No sites were found for Hind III, Sal I, Sma I, Sst II and Xor II. Comparison of the BPV restriction map to maps of rodent parvoviruses (MMV, H-1, KRV) and other parvoviruses shows that BPV possesses a restriction map distinct from the rodent parvoviruses.

INTERLEUKIN 2 DEFICIENCY AND IMMUNE PARALYSIS IN TUMOR-BEARING HOSTS. C.J. Burger, K.D. Elgert, and W.L. Farrar*. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061 and Frederick Cancer Res. Ctr., Frederick, MD 21701

Normal and tumor-bearing host (TBH) BALB/c mouse whole spleen cells were cultured for 24 hr in the presence of concanavalin A and their supernatants tested for the level of Interleukin 2 (IL 2) and Interleukin 3 (IL 3) activity. IL 2 and IL 3 are soluble T cell lymphokines. A 28 day kinetic study, using a methylcholanthrene-induced transplantable Fibrosarcoma, revealed that IL 2 levels dropped 59% between Days 8 and 10 of tumor burden and no IL 2 was detectable at Day 28. IL 3 activity also dropped 59% but between Days 4 and 8. Only 12% of normal baseline IL 3 activity was present at Day 28. Normal and TBH spleen cells were separated by nylon-wool into an adherent cell fraction, enriched for B cells, macrophages (MΦ), and suppressor T cells, and nonadherent cell fraction enriched for T helper cells. The respective fractions were assessed for lymphokine activity. The adherent population was more suppressive of IL 2 and IL 3 activity than its nonadherent counterpart. An initial *in vitro* comparison of normal and TBH spleen cell reactivity to lymphokines was performed. A sequential cascade model for amplification of cellular immunity by lymphokines was presented showing the putative effects of IL 1, IL 2, IL 3, and immune interferon. (Aided, in part, by a VAS Grant and a Whitehall Foundation Grant.)

PRELIMINARY STUDIES OF THE ACTIVITIES OF LACTOSE FERMENTING BACTERIA IN AN ESTUARINE ENVIRONMENT. S. Ciocchia and C. W. Erkenbrecher, Old Dominion University, Norfolk, VA 23508

This study was initiated to document the heterotrophic activity of bacterial populations in the polluted Lynnhaven estuary. The activity of the total viable bacterial population was measured using ¹⁴C-glucose and the fecal coliform population activity was estimated from measurements of ¹⁴C-lactose uptake at elevated temperatures. Activities at the *in situ* temperature of 7 °C were compared for both substrates to incubation at 44.5 °C. Standard plots of the data (1/ε versus A) illustrated typical Michaelis-Menten first order kinetics for both substrates tested. V_{max} values, indicative of an overall estimate of heterotrophic activity, were lower at the elevated temperature of 44.5 °C than at *in situ* temperature. V_{max} values for glucose were 0.449 and 0.153 ug/l/hr for 7 °C and 44.5 °C, respectively. Corresponding lactose V_{max} values were 2.584 and 0.153 ug/l/hr for the two temperatures. These studies have shown that fecal coliforms are potentially active in this estuarine environment. Continuing studies are focusing on a closer examination of the relationship between densities of indicator and pathogenic bacteria and their potential activity from heterotrophic uptake of radio-labelled substrates.

MOLECULAR ORGANIZATION OF THE STREPTOCOCCAL R PLASMID pIP501. R.P. Evans, Jr. and F.L. Macrina. Department of Microbiology, Virginia Commonwealth University, Richmond. The organization of the self-transmissible resistance plasmid, pIP501 (20 Mdal), capable of transfer among numerous streptococcal species, was determined by molecular cloning of restriction endonuclease fragments using a cryptic plasmid vector, pVA380-1 (2.8 Mdal). pIP501 encodes resistance to chloramphenicol (Cm^r) and erythromycin (Em^r, macrolide-1incosamide) antibiotics. Restriction endonuclease digested fragments of vector and pIP501 DNA were ligated *in vitro* and introduced into competent *Streptococcus sanguis* (Challis) by transformation. Cm^r transformants contained a 5.3 Mdal recombinant plasmid which resulted from the ligation of a 4.2 Mdal Hind III fragment of pIP501 with the Hind III digested vector. Em^r transformants contained a 4.0 Mdal recombinant plasmid, pIV794, which resulted from the ligation of a 1.4 Mdal Hind -Ava I fragment of pIP501 with Hind III-Ava I digested vector. The Hind III fragments bearing the Em^r and Cm^r determinants were found to be contiguous on pIP501. Hind III cleaved, self-ligated pIP501 DNA yielded only Cm^r transformants in *S. sanguis*. Such transformants contained a recombinant plasmid (pIV798, 5.3 Mdal) consisting of the 4.2 Mdal Hind III fragment and a contiguous 1.1 Mdal Hind III fragment. Our data suggest that the regions involved in antibiotic resistance and plasmid replication are clustered on the conjugative streptococcal R plasmid pIP501.

DIBEKACIN: AN IN VITRO COMPARISON WITH GENTAMICIN. E.L. Chan,* H.P. Yu* and S. Shadomy. Depts. of Medicine and Pathology, Med. Col. of Va. VCU, Richmond, VA 23298.

The antimicrobial activity of dibekacin (DKB), an aminoglycoside antibiotic derived from kanamycin B, was assessed *in vitro* by both the standardized agar dilution (WHO-ICS) and diffusion disc (FDA) tests. DKB was equal in activity to gentamicin (GM) when tested against isolates of *Escherichia coli*, *Staphylococcus aureus*, and *Enterobacter aerogenes*. It was significantly more active than GM when tested against *Pseudomonas* but significant less active than GM when tested against *Serratia* spp. Diffusion disc studies demonstrated the feasibility of using a 10-μg disc in routine testing with DKB; tentative "breakpoints" for such tests were recommended. These followed the pattern recently established by NCCLS for use with gentamicin and tobramycin diffusion disc tests ("resistant", zone dia. <12 mm; "intermediate", zone dia. of 13 or 14 mm; "susceptible", zone dia. >15 mm). The reliability of the DKB 10-μg disc is now being evaluated.

KETOCONAZOLE: SERUM LEVELS AS DETERMINED BY BIOASSAY AND BY HPLC. A. Espinel-Ingroff*, S. Shadomy, W.E. Dismukes* and the Cryptococcal Meningitis Chemotherapy Study Group. Dept. of Medicine, Med. Col. of Va., VCU, Richmond, VA. 23298.

Ketoconazole (KTZ) is an orally active imidazole under study for use in treatment of a variety of fungal infections including those caused by both systemic and opportunistic pathogens. The recommended dose is 200 mg/day; this is to be taken with meals. Sera from over 20 patients being treated with KTZ were assayed by both bioassay and HPLC. Excellent correlation was demonstrated when the two sets of data were analyzed ($r_{(125)} = 0.8224$). Two hour assay values in patients receiving the recommended dose ranged from "trace" amounts to values in excess of 4.0 μg/ml. Values as high as 9 μg/ml were measured in patients receiving 600 mg/day. However, some patients receiving this same dose had serum levels of less than 2.0 μg/ml. These data suggest considerable variability in the gastrointestinal uptake of KTZ. Additional studies revealed poor penetration of KTZ into either cerebrospinal or synovial fluids. These latter data suggest certain limitations in the clinical usefulness of KTZ (WED and the CMCSC supported by NIH-NIAID contract NO1 A182570).

CRYPTOCOCCUS NEOFORMANS: SEROTYPING OF CLINICAL ISOLATES FROM A MULTICENTER CHEMOTHERAPEUTIC TRIAL. R.A. Fromtling*, S. Shadomy, H.J. Shadomy, W.E. Dismukes*, and the Cryptococcal Meningitis Chemotherapy Study Group. Depts. of Microbiology and Medicine, Medical College of Virginia, VCU, Richmond, VA. 23298

Antigenic heterogeneity in *Cryptococcus neoformans* is well known and four serotypes (A,B,C,D) have been recognized. Serotypes A and D are associated with *C. neoformans* var. *neoformans* and serotypes B and C with *C. neoformans* var. *gatti*. Historically, BC serotypes have been limited to clinical isolates from southern California and S.E. Asia. Ninety clinical isolates from 13 states were tested for serotype by culturing on creatinine-dextrose-bromthymol blue agar. With this medium, organisms can be divided into serotype groups AD or BC based on their ability to rapidly assimilate creatinine. Twelve (13%) of the 90 isolates were serotype BC. There was a wide distribution of BC serotypes throughout the country; one strain from California, one each from Alabama and Louisiana, 2 each from Missouri, North Carolina and Virginia, and 3 from Tennessee. These data suggest that BC serotypes, previously thought to be strictly limited in their geographic occurrence, may have a greater distribution than originally hypothesized. The epidemiologic significance of this observed BC distribution, as well as the success of chemotherapy in AD versus BC infections are being investigated. (RAF supported by Inst. NRS Award AI-07086 from NIAID).

HETEROGENEITY IN ANTITUMOR FUNCTION AND ECOTOENZYMES IN MOUSE PERITONEAL MACROPHAGES (M ϕ). E. J. Jessee *, M. A. Rozner *, and P. S. Morahan. Virginia Commonwealth Univ., Richmond, VA.

To define M ϕ lineage and development, we separated peritoneal cells into four size groups using discontinuous Ficoll and rate zonal centrifugation. After M ϕ purification by adherence for 2 hr, each unseparated and size group was assayed for antitumor and ectoenzyme specific activities (SA). M ϕ were obtained from untreated (RES), C. parvum pretreated (CP), and thioglycollate broth pretreated (TG) ϕ BALB/c mice. All groups were subjected to differential and size analysis.

Only CP M ϕ exhibited antitumor activity; this activity was found in the unseparated and largest size CP groups. Alkaline phosphodiesterase (APD), 5'-nucleotidase (5'N), and leucine aminopeptidase (LAP) ectoenzyme SA were measured. Both unseparated CP and TG M ϕ showed ectoenzyme profiles different from RES M ϕ . In the size groups, the larger M ϕ had SA similar to the respective unseparated M ϕ . All of the small M ϕ size groups (RES, CP, TG) had lower 5'N than, and similar APD, to the SA of the unseparated RES M ϕ .

M ϕ	APD	5'N	LAP
Unsep. and large CP	Decreased	Decreased	Increased
Unsep. and large TG	Same	Decreased	Increased
Small RES, CP, TG	Same	Decreased	Insuff. data

The LAP SA are now being measured for the small M ϕ . This catalogue of functions and characteristics characterizes the heterogeneity in the M ϕ cell series and will help elucidate the process of M ϕ differentiation. (Supported by CA 24686).

IMMUNOCHEMICAL RELATIONSHIPS AMONG PLANT PEROXIDASES. Les- A. McDowell* and James M. Conroy. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Rabbit antibodies specific for the basic isoenzyme of horseradish peroxidase (HRP) were used to probe the relationships between HRP isoenzymes and peroxidases from other plants. Cross reactivity of antibody specific for the basic isoenzyme of HRP with two acidic HRP isoenzymes was demonstrated by immunodiffusion. The degree of cross reactivity was quantitated as 36% by precipitin tests. However, the antibody did not inhibit the catalytic activity of the acidic isoenzymes (Maximum inhibition of the basic isoenzyme was 80%).

Basic peroxidase isoenzymes from carrot, turnip, and radish were purified and tested for reactivity with antibody specific for the basic HRP isoenzyme. Cross reactions with all plant peroxidases were shown by immunodiffusion. In all cases, the degree of cross reaction with carrot (41%), turnip (49%) or radish (77%) was greater than that observed with the acidic HRP isoenzymes. Antibody did not inhibit the catalytic activity of the turnip or carrot enzymes. However the radish enzyme was inhibited significantly (60%).

The results indicate that the basic isoenzymes of turnip, carrot, and radish are more closely related to the basic HRP isoenzyme than the acidic HRP isoenzymes.

TRANSMISSIBLE CLINDAMYCIN RESISTANCE IN BACTEROIDES OVATUS. C. J. Smith*, and F. L. Macrina. Dept. of Microbiology, Virginia Commonwealth University, Richmond, VA 23298.

A clinical isolate of *Bacteroides ovatus* resistant to the lincosamide-macrolide (LM) antibiotics clindamycin, lincomycin, and erythromycin, and to tetracycline, was found to transfer the LM-resistance to suitably marked *B. uniformis* strains when the cells were co-cultured on nitro-cellulose filters. The transfer of resistance occurred at frequencies of 5×10^{-6} to 1.5×10^{-5} drug resistant progeny per input donor cell. In no case was the transfer of tetracycline resistance observed. The transfer event was mediated by a conjugation-like process which was insensitive to deoxyribonuclease and required cell to cell contact. Drug resistant progeny isolated from the primary crosses were able to transfer the LM-resistance markers to suitable recipient strains of *B. fragilis* and *B. ovatus*. Transfer of the LM-resistance phenotype was always accompanied by the transfer of a 27 $\times 10^3$ -dalton plasmid (designated pBf6). Restriction endonuclease digestion patterns of pBf6 showed several fragments in common with the previously characterized LM-resistance plasmid pBf4 (originally isolated in *B. fragilis*). Our data suggest that pBf4 and pBf6 share a common ancestry despite their occurrence in different species of the genus *Bacteroides*.

AN ELISA PROCEDURE FOR AMATID HERPESVIRUS. Margaret Lewis and J. C. Johnson. Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23508.

Duck plague is a hemorrhagic disease affecting the family Anatidae, resulting in 60-80% mortality in captive flocks. Plaque and neutralization assays for Anatid herpesvirus (AHV) require 5-10 days for completion and are restricted by the seasonal availability of fertile duck eggs. The enzyme-linked immunosorbent assay (ELISA) is rapid and specific and avoids the use of living cells. The Holland strain of AHV (ATCC VR #684) was grown on duck embryo fibroblasts and purified by banding on CsCl. The resulting virus was used to raise antisera in prebled New Zealand white male rabbits. Antibody production was confirmed in double diffusion plates and by neutralization. The IgG component of the AHV-specific antiserum was prepared by ammonium sulfate precipitation. The standard direct-ELISA of 0.25 ml used AHV-specific IgG coupled to horseradish peroxidase and azino di-(3-ethylbenzothiazoline sulfonate) as the enzyme substrate. Reaction parameters, including time, pH, antigen and conjugated-antibody concentration, solid phase, as well as interference by host cells, were varied for optimization of the assay. The assay appears to be sensitive to as little as 32 ng of protein. With the preparation of a highly purified virus and antiserum with high specificity, the ELISA system may become a basic procedure for AHV identification.

ANALYSIS OF BPV DNA SYNTHESIS IN VITRO. A. T. Robertson, E. R. Stout, R. C. Bates. Dept. of Biol., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

An *in vitro* reaction system has been used to study the replicative intermediates which occur during bovine parvovirus (BPV) DNA synthesis. The system is composed of nuclei isolated from BPV-infected bovine fetal lung cells and lysed with EDTA and MgCl₂. This nuclear lysate contains the viral DNA templates, preformed *in vivo*, and enzymes necessary to continue DNA synthesis *in vitro* in the presence of 32P-deoxyribonucleotides. In this study, the DNA products were separated by rate zonal centrifugation in 5-20% sucrose gradients with 4 M guanidine-HCl. Fractions containing viral DNA were electrophoresed on 1.4% agarose gels and the position of the radioactive DNA was detected by autoradiography. Hence, only molecules labeled *in vitro* were visualized. Bands corresponding to all previously identified viral replicative intermediates were observed. The molecules which migrated to the position of dimer DNA in the gradient consisted of low levels of unit length single stranded BPV DNA, double stranded replicative forms and dimer DNA. This entire dimer DNA fraction from the gradient, was replicated with *E. coli* DNA polymerase I (Klenow fragment) and digested with restriction enzymes. The DNA fragments produced were found to be identical to single stranded virion DNA replicated and cut in the same manner.

THE ENUMERATION OF PETROLEUM-DEGRADING BACTERIA FROM THE ELIZABETH RIVER ON A SILICA-GEL OIL MEDIUM. S. W. Sokolowski and C. W. Erkenbrecher. Old Dominion Univ., Norfolk, VA 23508.

A silica gel-petroleum (SGP) medium was developed to enumerate petroleum-degrading bacteria in estuarine environments. This medium is extremely versatile. The salinity of the medium can be varied from 0 to 35 ppt, pH drift is negligible (± 0.2 pH units after 166 days) and a wide variety of liquid hydrocarbons such as kerosene, motor oils, crude oils and Bunker C (#6) fuel oil can be incorporated easily into the medium without sonication. Furthermore, extraneous carbon contamination and water loss due to syneresis are significantly reduced. The shelf-life of the medium at room temperature (up to 5 months) is limited only by the chemical stability of the petroleum if a humid atmosphere is properly maintained.

A field study was undertaken to test the SGP media and to gather preliminary data on the general water quality of the Elizabeth River. The mean densities of petroleumolytic bacteria in Elizabeth River surface waters were 17, 12 and 11 CFU per 100 ml, as enumerated on Bunker C, South Louisiana Crude Oil and 20 weight motor oil SGP media, respectively. These enumerations are two to three orders of magnitude lower than those of the corresponding MPN medium which was used for comparative purposes. It is hypothesized that the difference in estimates of petroleumolytic bacteria in the Elizabeth River is due to a concentration of bacteriocidal pollutants on the SGP membrane filter whereas these pollutants are diluted in the MPN media.

MARKER RESCUE IN *STREPTOCOCCUS SANGUIS* - IMPLICATIONS FOR SHOTGUN CLONING. J. Ash Tobian*, and F.L. Macrina. Dept. of Microbiology, Virginia Commonwealth University, Richmond, Virginia 23298

The covalently closed circular form of pVA736, a 5.0×10^6 dalton chimeric plasmid conferring erythromycin resistance, genetically transformed *Streptococcus sanguis* with high efficiency ($>10^3$ transformants per recipient). This efficiency was constant in isogenic recipients which 1) were plasmidless, 2) contained a plasmid that shared homology with pVA736, or 3) contained a plasmid that shared no homology with pVA736. When linearized by restriction endonuclease cleavage, pVA736 was unable to efficiently transform either the strain lacking a plasmid or the strain containing the nonhomologous plasmid ($<10^3$ transformants per recipient). However, linearized pVA736 could efficiently transform the strain containing the homologous plasmid, yielding $>10^3$ transformants per recipient, a process termed "marker rescue." In *Streptococcus sanguis* multimeric plasmid forms are known to transform by a first order process while monomers transform by a second order process. Because the generation of multimers or a significant number of like monomers during "shotgun" cloning of chromosomal fragments is unlikely, a "helper cloning" method based on the "marker rescue" model can be utilized to preclude this problem.

MICROBIAL FLAGELLA STAINING: METHOD OR MAGIC

T.L. Weaver. Dept. of Biology, Liberty Baptist College, Lynchburg, Va. 24506

The techniques for staining of microbial flagella have been accompanied through the years by an aura of uncertainty due to the highly variable results one obtains while seemingly following standard proven procedures. The most predictable and widely used procedure today is the method developed and modified by Leifson (1951). This stain which includes sodium chloride, tannic acid, basic fuchsin, ethanol, and water is recommended in most standard methods manuals which include techniques for staining microbial flagella. Although the stain composition seems relatively uncomplicated, this study has revealed that much of the variability in results can be traced to variability in the basic fuchsin component. A variety of salts of pararosaniline, rosaniline, magenta II, and new fuchsin may all be considered "basic fuchsin." While any of these can yield a successful stain, the factor that must be carefully adjusted with the various different basic fuchsin is pH since the final pH can vary quite a bit depending upon the particular dye used. Adjustment of pH to 5 removes most of the magic from flagella staining via Leifson's method. Slide preparation, culture, timing, and storage of the stain are important secondary factors influencing the success of the operation.

PROTEIN CHANGES DURING ENFLAGELLATION OF *NAEGLERIA FOWLERI*.

T.W. Woodworth, W.E. Keefe, and S.G. Bradley. Virginia Commonwealth University, Richmond 23298.

Acanthamoeba fowleri n68 become enflagellated within 4 h after transfer to non-nutrient buffer. Enflagellation requires *de novo* protein synthesis, necessitating regulation of protein levels to provide precursors. Protein changes during enflagellation have been studied using radiolabeled proteins resolved by two-dimensional electrophoresis. Densitometric scanning of autoradiograms was combined with computer-assisted analyses to determine whether general correlations exist between amounts or numbers of polypeptides and their size or charge. Some correlations were observed between mean amounts of polypeptides and their size or charge; these prevail in flagellates as well as in *Acanthamoeba*. Specific comparisons of the ca. 500 resolved polypeptides present in *Acanthamoeba* and flagellates reveal only 20 to 30 species which either appear, disappear, or markedly change in amount during enflagellation. Few of the changes were specific to the enflagellation process when compared to the changes observed in an identically treated non-enflagellating strain. A small number (ca. 50) of resolved polypeptide species are phosphorylated in growing *Acanthamoeba*. Shifts in the number and patterns of polypeptide phosphorylation during enflagellation are under investigation. Studies of protein regulation during *N. fowleri* enflagellation should provide insights into regulatory mechanisms in eukaryotic cells.

THE ECOLOGICAL CONDITION OF BACTERIAL COMMUNITIES IN A LAKE WHICH RECEIVES ACID MINE-POLLUTION. R.A. Wassel*, and A.L. Mills*. Dept. of Environmental Sciences, Univ. of Va. Charlottesville, Va. 22903

Bacteria in various locations of Lake Anna, a freshwater reservoir in central Virginia which receives acid mine-water, were compared as to community attributes over a one year period. The total cell-densities in an area of the lake closest to an inflow stream carrying mine effluents were not significantly different from either a downstream portion or a section unexposed to acid pollution. However, the number of viable heterotrophs increased with the distance from the pollution source. When tested under cultural conditions, the diversity of bacteria isolated from the several sites did not markedly differ, nor did the microbes' abilities to perform various ecological functions. Heterotrophic activity however, (uptake of ^{14}C -labeled glucose) was less at the most polluted site than the other two areas. These findings suggest that the presence of acid mine-pollution is associated with a decrease in the reaction rates of heterotrophic processes, and that this effect is relieved as the mine drainage is diluted by the large volume of water in Lake Anna. These findings also imply the validity of the theory that ecological properties of biotic communities tend to diminish in magnitude in the presence of pollution which is toxic to some, but not all members of that community.

MICONAZOLE: IN VITRO TEST VARIABLES.

S.C. White*, H.P. Yu*, A. Espinel-Ingroff and S. Shadomy. Dept. of Med., Med. Col. of Va., VCU, Richmond, VA. 23298

In vitro susceptibility tests with imidazoles such as miconazole (MCZ) and ketoconazole require standardization if they are to be used in the routine clinical laboratory. A series of experiments were conducted in order to identify those variables which would affect the results of such tests with pathogenic yeasts and MCZ. Three test procedures were used: agar dilution, broth dilution and Microtiter. Three media were evaluated: Sabouraud's (SAB), FDA-M3 (M-3), and casein-yeast extract-glucose (CYG). Three inoculum sizes were tested: 10^2 , 10^4 and 10^6 CFU. Results were evaluated after 48 hr and 5 days incubation. The most significant variable involved the presence or absence of agar in the test media. The presence of agar raised broth dilution MIC values by at least a 4-fold factor in a number of tests with isolates of *Candida*. Variations in inoculum size was an important variable in broth but not in agar dilution tests. Increasing the incubation period was a minor source of discrepant data. The results of these studies show that considerable effort will be required to provide a routine clinically reliable test procedure for miconazole and related antifungal compounds.

KETOCONAZOLE: SUSCEPTIBILITY TESTING OF CLINICAL ISOLATES OF PATHOGENIC FUNGI.

H.P. Yu*, S.C. White*, S. Shadomy, W. E. Dismukes*, and the Cryptococcal Meningitis Chemotherapy Study Group. Dept. of Medicine, Med. Col. of Va., VCU, Richmond, VA. 23298

Ketoconazole (KTZ) was tested *in vitro* against sixty four isolates of systemic and opportunistic fungal pathogens by broth dilution using 3 different media. KTZ was most active when tested in nonsynthetic media such as FDA M-3 broth (M-3) and least active when tested in a synthetic medium such as casein-yeast extract-glucose broth. Isolates of dimorphic systemic pathogens were highly susceptible to KTZ. The MIC₉₀ values of KTZ in M-3 for *Blastomyces dermatitidis*, *Histoplasma capsulatum* and *Coccidioides immitis* were 0.39 µg/ml or less. Isolates of *Cryptococcus neoformans* and *Sporothrix schenckii* were less susceptible. Only 3 of 8 isolates of the former were susceptible to 3.13 µg/ml of KTZ; 0.39 µg/ml of KTZ was inhibitory for 5 of 7 isolates of the latter. A number of isolates of *C. immitis* were repeat isolates from patients being treated with KTZ; emergence of clinical resistance was not observed among these isolates. Definition of the *in vitro* limits of clinical susceptibility or resistance have not yet been defined for KTZ. However, data obtained in this study suggest that a MIC of 1.56 µg/ml represents the upper limit of probable clinical susceptibility. (WED and the CMSCG supported by NIH-NIAID contract N01 AI82570).

Psychology

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

THE EFFECTS OF INFUSION OF PCPA WITH BOTH OSMOTIC MINIPUMPS AND IP INJECTION ON ACTIVITY, EATING, AND DRINKING. C.T. Albanese,* Dept. of Psychology, Washington and Lee University, Lexington, VA 24450 (Sponsor: L. E. Jarrard)

The production of serotonin in the rat brain was inhibited by administration of p-chlorophenylalanine (PCPA). The experiment consisted of two separate techniques of administration: 1) using intraperitoneally placed osmotic minipumps (Alzet Corp.), and 2) a single IP injection. Data collected from 5 male albino rats of the Wistar strain (200-225g) formed the basis for the experiment. Using a computer system, activity, eating, and drinking were monitored over each 24 hour cycle. Of the two techniques used, the results from the minipumps proved less significant than those of the IP injection. With both techniques, however, results indicated an increase in activity, and a decrease in both food and water consumption. However, in both cases, normal activity, eating, and drinking returned after 3 days of PCPA administration.

BEHAVIORAL AND NEURONAL EFFECTS OF PRENATALLY ADMINISTERED VALIUM IN THE RAT. Edward G. Brooks,* Department of Psychology, Washington and Lee Univ., Lexington, VA 24450; H. D. Graham,* LSU at New Orleans; Robert M. Elsdorfer,* Univ. of Tel Aviv. (Sponsor: L. E. Jarrard)

Previous research indicates that Valium injections administered to pregnant rats in the third trimester of pregnancy has a detrimental effect both on hippocampal neurogenesis and behavior (righting response, and spontaneous alternation). The purpose of the present experiment was to see if prenatal exposure to Valium affects more complex spatial behavior in adult animals.

Four pregnant females were given daily injections of Valium (10mg/kg) from days 13 to 20 of gestation. Three females served as controls. At the time of birth rat pups were divided into the following 4 groups: VV - 6 Valium exposed pups with Valium injected mothers, CV - 3 control pups with Valium injected mothers, CC - 3 control pups with control mothers, and VC - 6 Valium pups with control mothers. Training on an 8-arm spatial maze with all arms baited began on postnatal day 71 and this was followed with training where only 4 arms were baited. Results indicated significant behavioral differences between rats raised by Valium mothers as compared to control mothers. Prenatal Valium exposure had no significant effect. These results suggest that the experiences in the postnatal period may be more important than the prenatal exposure to Valium.

THE ROLE OF AFFECT IN THE SPACING EFFECT. David G. Elmes and N. J. Herdlein* Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450

The spacing effect refers to the superiority of recall after spaced or distributed practice. The difficult study-phase retrieval under spaced practice may be arousing, while massed practice may engender negative affect. This, plus the fact that spaced items are judged to be more familiar and occur more frequently than massed events, suggests that affect may play an important role in the spacing effect. In the present studies, subjects heard neutral, "good", or "bad" words under conditions of massed and spaced practice. Massing the practice of neutral words resulted in them being judged negatively, while spaced practice of the same words led to positive affective judgments. A substantial spacing effect in free recall was found only for the neutral words. In fact, the spacing effect was reversed for the "good" words. Positive and negative affect can determine the effectiveness of practice conditions, and the changes in affect associated with massed and distributed practice may account for their influence on recall. The present results are congruent with Zajonc's hypothesis that affect plays a crucial role in the information processing underlying most cognitive tasks.

Supported by a Robert E. Lee Research Grant

THE DOUBLE STANDARD OF DRINKING. B. Gillen* and C. Senft.* Department of Psychology, Old Dominion Univ., Norfolk, Va. 23508

The masculine and feminine sex roles are clearly defined in our society. Males are perceived as possessing traits which exemplify competence while females are expected to possess traits which denote warmth and expressiveness (Broverman, Vogel, Broverman, Clarkson, and Rosenkrantz, 1972). Further, it has been shown (Seyfried and Hendrick, 1973) that when people act out of role, masculine females, or feminine males, they are derogated. Such research implies that when females participate in the masculine behavior of heavy drinking that they will be evaluated more negatively than males that consume an equal amount. The following experiment tests these hypotheses.

Subjects read a transcript of a discussion between a psychologist and a male or female college student. During this conversation it was revealed that the student drank moderately or heavily. Subjects then described the students using the Bem Sex Role Inventory (Bem, 1974) and rated the student on a number of Likert-type items. The results confirmed the experimental hypotheses. Female heavy drinkers were seen as more likely to possess sex irrelevant bad traits. In addition, these females were expected to possess the negative characteristics associated with masculinity such as uses harsh language. Finally females who drink heavily received a less hopeful prognosis for recovery.

THE EFFECT OF INTROVENTRICULAR INFUSION OF PHYSOSTIGMINE ON COMPLEX SPATIAL LEARNING IN THE RAT. David J. Hepler,^{*} Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450 (Sponsor: L. E. Jarrard)

Physostigmine has been recently shown to facilitate learning in rats. Because of the peripheral effects generated by this drug when administered intraperitoneally, only simple forms of learning such as passive avoidance have been investigated. It was felt that these deleterious effects could be bypassed by delivering physostigmine to the brain by direct intraventricular infusion. In the present study, the effect of physostigmine on activity and complex spatial learning was investigated. One week prior to the administration of the drug, experimental and control groups were taught to run a 12-hour radial maze in which only 6 arms were baited. The experimental group then received a unilateral 1 μ g/ μ l hour continuous infusion of physostigmine from an osmotic minipump into the lateral ventricle over a 7 day period. Results indicated no significant difference between experimental and control groups for either activity levels or errors incurred in learning the spatial task. These results do not support those found by previous investigators who used intraperitoneal injections as the method of drug delivery. Implications of this study will be discussed.

SELECTIVE HIPPOCAMPAL LESIONS AND BEHAVIOR. Leonard E. Jarrard, Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450

The hypothesis that neuroanatomically discrete areas within hippocampus are differentially involved in behavior was studied in rats, using selective lesions involving either the fimbria, CA1 cells, and/or posterior alveus. Damage to the fimbria with the resulting interruption of rostral connections with subcortical structures is similar to extensive hippocampal lesions in causing increases in behavioral arousal and increased susceptibility to interference. Damage to CA1 cells and/or posterior alveal lesions that interrupt caudal hippocampal projections toward cortical areas have relatively little effect on behavior but do result in impaired acquisition of complex spatial tasks. Since damage to fimbria and alveus interrupts fibers of passage, thus complicating interpretation of the results, the use of chemical lesioning techniques with more discrete damage to hippocampal subdivisions should prove of value in future research.

THE SOCIAL SKILLS OF ADULTS WITH AUDITORY/VISUAL PROCESSING DEFICITS. P. A. Jarvis,^{*} and E. M. Justice,^{*} Dept. of Psychology, Old Dominion Univ., Norfolk, VA 23508

The social skills and self-concept of college students with varying degrees of auditory/visual processing deficits were examined. Such deficits have been termed learning disabilities in children and have been associated with significant academic and social difficulties.

Based on performance on a test of auditory/visual abilities subjects were divided into three groups: Group I with severe processing deficits often indicative of LD, Group II with moderate processing problems, and Group III with no significant problems. All subjects were administered the counseling form of the Tennessee Self-Concept Scale and the Self-Concept as a Learner Scale and participated in a 5 min. videotaped interaction with a same-sex experimental confederate.

Analyses indicated no significant differences among the groups on either of the self-concept scales, however trends were noted in the data. Group III tended to score lower on social subscales of both measures while scoring highest on task orientation and problem solving subscales. Analysis of the videotaped interaction also indicated no significant differences among the groups, however, Group III tended to talk more while directing fewer questions to the confederate. These results suggest that auditory/visual processing deficits may be related to social difficulties, although further research is necessary to substantiate the trends noted.

DEMONSTRATION OF PSYCHOLOGICAL AND SCIENTIFIC ERRORS IN RESEARCH AND PUBLICATIONS WITH THE PSYCHOLOGICAL STRESS EVALUATOR. Michael P. Kradz and John C. Bartone, The American Health Research Institute, Annandale, Virginia 22003.

The scientific methodology of a new instrument, the Psychological Stress Evaluator (PSE) is currently without standards in any field of published literature. Some scientists and courts of law praise the PSE while others condemn it. The instrument has been given validity and reliability tests. Hardware instrumentation cannot be faulted as designed. All software programs must be examined for improvement. Yet the PSE is often censured as an instrument while its use and management is abused and ignored.

Many results, publications and seminars contain erroneous factors as (1) poor data collections; (2) maladapted instrumental operations; (3) incorrect voice recordings; (4) improper client or patient preparation (normal vs. psychosomatic, neurotics vs. psychotics, et al.); (5) faulty interrogations of subjects; (6) irregular data sequence and alignment; (7) inaccurate judgments for continuance of interrogation of subjects or prisoners; (8) inapposite follow-up examinations; (9) crude or non-existent de-conditioning of interviewees; (10) coarse kymograph production; (11) invalid chart interpretations; (12) illogical and pseudopsychodiagnostics; (13) inadequate and unscientific reports; (14) poor attitudes of operators and interviewers; (15) unnecessary jeopardy for clients and incarcerated suspects; and (16) insufficient use and extension of operator faculties, supervision and control.

AGE, S-R COMPATIBILITY AND STIMULUS UNCERTAINTY EFFECTS ON INFORMATION PROCESSING. D. Michael McNulty,^{*} Dept. of Psychology, Old Dominion University, Norfolk, VA, 23508

This study was designed to assess the influence of the central, stimulus processing and response selection mechanisms on the consistently reported age decrement in information processing. Five younger (19-28, m dn = 22) and 5 older (69-78, m dn = 71) female subjects were recruited from university undergraduates and community organizations. Subjects were individually presented 32 trials at each of the 6 factorial combinations of 3 stimulus uncertainty (SU) levels (2, 4 or 8 equiprobable numerals) and 2 levels of stimulus-response (S-R) compatibility (high and low). On each trial, a single numeral was projected on a 1.5 inch square screen above a S-R configuration card. The subjects depressed a telegraph key associated with the presented numeral as rapidly as possible. Responses under high compatibility were in left to right ascending order. Under low compatibility, even numerals were randomly paired with the right hand keys and odd numerals were randomly paired with the left hand keys. The choice reaction time (CRT) was measured for each trial. Analysis of variance indicated that increased age, greater SU, and lower S-R compatibility each resulted in significantly ($p < .01$) slower mean CRT. All the interactions except those involving age and S-R compatibility were also significant ($p < .05$). The results indicated that the age decrement in information processing was primarily attributable to the central stimulus processing rather than the response selection mechanism.

PERSPECTIVE-TAKING ABILITIES OF NORMAL AND LEARNING DISABLED CHILDREN: DO YOU SEE WHAT I SEE? E. M. Justice,^{*} and R. L. Beard,^{*} Dept. of Psychology, Old Dominion Univ., Norfolk, VA 23508

The perspective-taking skills of normal and learning disabled (LD) children between 9 and 12 years of age were examined. The subjects were 44 children diagnosed as LD and 44 children without learning problems, matched with the LD sample on age, race and sex. Each child was tested on three perspective-taking tasks. Affective perspective-taking, awareness of another's feelings, was tested using stories and pictures that were (a) consistent ("getting a new toy" and a smiling face) or (b) inconsistent ("eating one's favorite ice cream" and a sad face). Perceptual perspective-taking, awareness of what another is seeing, involved judging another's view of a spatial array. Cognitive perspective-taking, awareness of what another knows, involved telling a story as it would be told by another.

Results indicated that both normal and LD children showed nearly perfect performance on the affective task when verbal and pictorial cues were consistent. When cues were inconsistent, LD children relied on pictorial cues while normal children relied on verbal information. The LD children scored significantly lower than the normal children on both the perceptual and cognitive tasks. These findings suggest that LD children are often ineffective in taking the perspective of others. Programs designed to develop perspective-taking skills may alleviate the social difficulties often experienced by children with learning problems.

THE EFFECT OF LEADERSHIP STYLE AND WORK ENVIRONMENT ON JOB RELATED BEHAVIORS. John K. Schmidt*, Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450 (Sponsor: L. E. Jarrard)

A study designed to examine Fiedler's contingency model of leadership effectiveness was conducted in a small unionized manufacturing plant in northern New Jersey. The research tested the effects of leadership orientation and specific work climates on performance (as was conducted in Fiedler's original studies), job satisfaction, absenteeism and turnover. It was found that performance is not the only work behavior that is contingent on the job situation, but that job satisfaction and absenteeism are also to be considered. Turnover proved to be only slightly important. Further, the job related behaviors themselves were observed as being connected with one another to varying degrees. Overall, the concept that effective leadership is based on appropriate matching of leadership orientation and work environment was upheld, and that more issues should be examined before judging leader effectiveness than just high productivity.

NORADRENALINE AND SPATIAL MEMORY IN THE RAT. Robert D. Shaver* and Thomas K. Creson, III*, Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450 (Sponsor: L. E. Jarrard)

Fourteen Sprague-Dawley rats were used to investigate the effects of general noradrenaline depletions on spatial memory. Noradrenaline was depleted by injecting 6-hydroxydopamine into the dorsal noradrenergic bundle, which is the main fiber bundle supplying noradrenaline to the telencephalon, especially hippocampus. All rats were trained preoperatively to run to 4 alleys of an 8-arm maze. Five rats were administered 6-hydroxydopamine, 5 rats served as sham operated controls, and 4 served as unoperated controls. Retention and reversal learning were investigated after the operations. The results will be discussed as they relate to the effects of noradrenaline depletions on spatial memory in rats.

METAMEMORY ABILITIES IN GOOD & POOR SPELLERS John Stathakis* Dept. of Psychology, Washington & Lee Univ., Lexington, Va.

This study investigated the relationship of memory monitoring abilities and spelling skills in 4th grade children. As in other metamemory studies, it was assumed that children who are unable to accurately predict how much they know are likely to devote less time to studying and thus show poorer performance. Groups of good and poor spellers were tested for general metamemory (Flavell, Friedrichs & Hoyt, 1970) and specific spelling metamemory (e.g., predicting the number of words they could learn to spell correctly in a 10 min. period). Strategies found useful by good spellers were then taught to half of the poor spellers. After 1 week, all subjects were tested for spelling metamemory on a new list.

It was found that poor spellers who received training did become more accurate in predicting their spelling performance. Although better spellers were found to have greater spelling metamemory abilities, no differences were found between groups on the general metamemory task. The results were interpreted in light of Markman's (1973) study of general metamemory and ability to predict performance on motor tasks. She suggests that metamemorial abilities do not emerge synchronously but vary depending upon familiarity and experience with the task. Thus, it is suggested that by familiarizing poor spellers with rules, and providing experience with spelling metamemory we might be able to bring poor spellers' ability up to a level congruent with their other metamemorial capacities.

THE WINGS OF THE MULLER-LAYER: AN IN-DEPTH REPORT.

Joseph B. Thompson,* Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450

Eighteen subjects estimated the length and the location in depth of stereoscopically presented Muller-Layer figures and straight lines. The results indicate that the presence and orientation of wings influenced length judgments, but did not affect depth judgments of either monocularly or stereoscopically presented stimuli, or of stimuli with stereoscopic cues designed to complement or oppose the hypothesized perspective cues suggested by the wings. Vertical position of the target and binocular disparity influenced both length and depth judgments.

Statistics

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

AN APPLICATION OF THE LISREL IV PROGRAM TO THE ANALYSIS OF HUMAN HALF-SIB DATA. R. M. Cantor* and W.E. Nance*, Dept. of Human Genetics, Med. Col. of Va., Richmond, Va. 23298

Monozygotic (MZ) twins have identical sets of genes and, thus, their offspring are related to each other as conventional half-siblings. Expectations of mean squares among half-sibships, between sibships nested within half-sibships, and within sibships yield five simultaneous equations which permit the estimation of additive, dominance, epistatic, environmental and maternal effects by iterated weighted least squares (Nance and Corey 1976). To date, all reported analyses have been on univariate traits.

Lisrel IV is a general purpose computer program developed by Jöreskog and Sörbom (1978) for maximum-likelihood estimation of coefficients in sets of linear structural equations under the assumption of multivariate normality. It supplies a large sample likelihood ratio goodness of fit test for structural models, and may be modified for the procedure of confirmatory factor analysis.

The program was employed to test multivariate models for inheritance of genes for finger ridge counts. Data were obtained from 430 offspring in the families of 39 male and 49 female MZ twins. Individual finger ridge counts were determined by the method of Holt (1968) and standardized prior to analysis. Simple additive genetic, random environmental models for total ridge count were readily rejected while more complex models assuming interactions between the determinants of individual finger ridge counts provided an adequate explanation for the data.

PREDICTIVE INFERENCE FOR THE INVERSE GAUSSIAN DISTRIBUTION. Raj S. Chhikara*, Dept. of Mathematical Sciences, Old Dominion University, Norfolk, VA 23508

The problem of prediction intervals for the inverse Gaussian variable is studied and the β -expectation tolerance limits are obtained. Exact two-sided tolerance limits using the percentage points of χ^2 and F distribution are given. However, no closed form sampling theory solution is feasible for the one-sided limits. In this case, the β -expectation tolerance limits are obtained based on a predictive density function determined using the vague prior for the parameters. Numerical computations using two sets of life-time data are included.

EVALUATION OF THE ESTIMATION OF PARAMETERS FOR THE GAMMA DISTRIBUTION USING THE MONTE CARLO METHOD. Susan R. Case* and J. Van Bowen. Dept. of Mathematics, Univ. of Richmond, Va. 23173.

Data supplied by the USFDA concerning the control of the cigarette beetle, *Lasioder serricornis*, was the basis of the present research. The grouped data was provided by selecting k samples of beetles and subjecting each sample to a toxic gas for varying numbers of days. After the appropriate time interval, a count of the number of expired beetles provides k measurements of the number of expired (n_i) of the number tested (N_i) in the elapsed time (t_i , $i = 1, \dots, k$).

SIMULTANEOUS TESTS FOR FINITE FAMILIES OF HYPOTHESES. Robert W. Foutz*, Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, VA 24061

A procedure is proposed whereby R test statistics $F = (F_1, F_2, \dots, F_R)$ together with "randomly generated critical points" (C_1, C_2, \dots, C_R) may be used to construct a simultaneous test for a family containing R hypotheses. This procedure provides simultaneous tests having an exact prescribed type I error rate; the procedure does not require the distribution of F to be known. The simultaneous test is illustrated for making all pairwise comparisons in a one-way ANOVA model.

THE EFFECTS OF STATISTICAL CRYPTANALYSIS IN WORLD WAR II. I. J. Good, Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

It seems possible that the most important use that has ever been made of statistics was for cryptanalysis in World War II because without it perhaps the world would have been conquered by a criminal lunatic whose name was appropriately an anagram of THE LIAR and of HEIL RAT. Statistics, however, is only one of the tools used by the cryptanalyst.

The details of the methods used have apparently not yet been declassified so this presentation will deal largely with the effects of the work, much of which have been published in recent years, as, for example, in Ronald Lewin's book ULTRA GOES TO WAR.

The statistical techniques included sequential analysis, Bayesian methods, and tree searches, none which had been officially used much before the war (although chess players had informally used tree searches for centuries). A. M. Turing was influential in much of this work. Two types of large cryptanalytic machines were built. The first, called the Bombe, was electromechanical. A primitive form of this machine had previously been used by Polish cryptanalysts. The second large machine, the Colossus, was electronic with 1500 tubes and was in many respects a precursor of the general-purpose electronic computer. The first Colossus began operation on 1943 June 1, five days before D-day, the successful Allied invasion in Normandy.

THE COMPARISON OF SEVERAL MULTINOMIAL DISTRIBUTIONS WITH A STANDARD. Mark O. Marcucci and D. R. Jensen, Dept. of Statistics, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061.

Suppose independent random samples have been taken from $k-1$ multinomial distributions having c classes each, of which one distribution is considered a standard. It is desired to test whether each of the remaining distributions differs from the standard. A multiple test procedure is described using Pearson's tests for the homogeneity of the $cx2$ tables formed by pairing each test distribution with the standard. The limiting joint distribution of these statistics is a multivariate chi-squared distribution which yields approximate critical values for the given tests at level α . Some probability inequalities relating to the testing procedure are discussed. For the case of binomial distributions approximate critical values are available from the literature. Applications are noted in biology and statistical quality control.

HYPOTHESIS TESTING IN B-SPLINE REGRESSION. Patricia L. Smith*, Dept. of Mathematical Sciences, Old Dominion Univ., Norfolk, VA 23508

Linear combinations of B-spline coefficients which provide statistically meaningful hypothesis tests are identified. These tests include the importance of breakpoints, continuity constraints, and higher order terms. The important linear combinations turn out to be contrasts whose coefficients are determined by differencing the left- and right-hand limits of the B-splines or their derivatives at certain knots. A FORTRAN program for testing single degree of freedom hypotheses is discussed. (Partially supported by Old Dominion Univ. Summer Research Faculty Fellowship #80-950).

BAYESIAN STATISTICS, THE LAW, AND QUANTIFICATION OF ILLEGAL HASH OIL. P. J. Smith*, Dept. of Biostatistics, Med. Col. of Va., Richmond, Va. 23298

In Virginia, possession of hash oil having tetrahydrocannabinol (THC) content exceeding 12% corresponds to a felony whereas hash oil containing less than 12% THC corresponds to a misdemeanor. This paper presents an experimental design by which serial dilutions of increasing THC concentration may be calibrated with the relative response of each solution as measured by gas chromatography (GC). Also, of interest is the assessment of the hypothesis that a given sample of specified GC response has THC content less than 12%. Bayes factors and posterior expected utility ratios are given to evaluate the hypothesis.

USE OF THE POWER TRANSFORMATION IN THE INTERPRETATION OF MUTAGENESIS TEST DATA. R. D. Snee, Engineering Dept., and J. D. Irr, Haskell Lab., E. I. du Pont de Nemours & Co., Inc., Wilmington, DE 19898

Mutation tests, such as the Ames, mouse lymphoma, and Chinese hamster ovary, are rapidly becoming a widely used tool for screening chemicals for cancer producing potential. It is shown that the power transformation, $Y = (\text{mutation frequency} + A)^{\lambda}$, with parameters estimated by the method of Box and Cox, enables one to use standard analysis of variance and regression techniques in the evaluation of the results of these tests. The recommended power transformation parameters are $A = 0$, $\lambda = .2$ for the Ames test, $A = \lambda = 0$ (log transformation) for the mouse lymphoma assay, and $A = 1$, $\lambda = .15$ for the Chinese hamster ovary test. These results were obtained by analyzing data from these tests collected by different laboratories on a wide variety of chemicals. Aspects of the Box-Cox estimation procedure which need further research are also discussed.

NOTES

NOTES

5-573
127
Q1
V5X
NH

VIRGINIA JOURNAL OF SCIENCE

VOL. 32, NO. 4
WINTER 1981



OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

THE VIRGINIA JOURNAL OF SCIENCE

EDITOR:

Stewart Ware
Dept. of Biology
College of William and Mary
Williamsburg, Va. 23185

BUSINESS MANAGER:

Franklin D. Kizer
Route 2, Box 637
Lancaster, Va. 22503

©Copyright, 1981 by the Virginia Academy of Science. The Virginia Journal of Science (ISSN 0042-658X) is published four times a year (Spring, Summer, Fall, Winter) by the Virginia Academy of Science, P.O. Box 8454, Richmond, Va. 23226. Second Class Postage paid at Richmond, Virginia and additional entry at Harrisonburg, Virginia 22801. The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

Subscription rates for 1982: \$20.00 per year, U.S.A.; \$30.00 per year, other countries. All foreign remittances must be made at par U.S. dollars or their foreign equivalent. Back issues are available for \$7.50 per issue postpaid.

Changes of address, including both new and old zip codes, should be sent promptly upon moving to the following address. **POSTMASTER:** Send address changes to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, Va. 23226. All correspondence relating to remittances, advertising (rates will be sent upon request), subscriptions, missing issues, and other business affairs should be addressed to **Business Manager**.

All manuscripts and correspondence about them should be addressed to the **Editor**. The Virginia Journal of Science welcomes for consideration original articles and short notes in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and the impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* All articles should be typewritten, double-spaced throughout, on one side of good bond paper (8½ × 11 inches). Margins should be not less than 1¼ inches on any border. Each manuscript should be complete and final when submitted. It should include the title, author's name and affiliation, and proposed running title, all appear-

ing on a title page, and a required abstract summarizing the text, particularly the results and conclusions, also appearing on a separate page.

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first and last page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. Metamorphic Textures. Pergamon Press, New York. 350 pp.

Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. *In* Distributional History of the Southern Appalachians, Part III. Vertebrates (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

References to project or company reports, technical memoranda and personal communications are not permitted, except as footnotes under exceptional situations. Footnotes in text should be numbered serially throughout a manuscript.

For illustrations, glossy prints are preferred to drawings. Each figure and table should be mentioned specifically in the text, with all figure numbers and legends typed consecutively on separate sheet, and the figures identified by author's name and figure number in pencil on the back. Table numbers and legends should be included as part of the table.

The VJS reserves the right to make page changes for very long manuscripts, and to bill the authors at cost for unusually extensive complicated illustrative material or extraordinary alterations in the text in proof.

VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE

Vol. 32

No. 4

Winter 1981

TABLE OF CONTENTS

ARTICLES

- Nectar Dispersion Patterns in a Population of *Impatiens capensis*. *Michael Zimmerman, Oberlin College* 150
- Dextroamphetamine Affects Hypothalamic-Pituitary-Thyroid Activity: A Preliminary Study. *Melvin Ching, Medical College of Virginia, V.C.U.* 153
- Inactivation of Poliovirus-2 in Natural Waters: A Thermolabile Factor. *James C. Johnson, Patrick G. Haggerty, Margaret J. Roberts, and Robert P. Olson, Old Dominion University* 155
- Vascular Flora of the Jones and Mill Creek Watershed, Powhatan, Virginia. *Celeste M. Corcoran-Diggs and G. W. Hall, College of William and Mary* 163

ABSTRACTS 173

OBITUARIES

- Dr. Clyde Y. Kramer 174
- Dr. A. B. Massey

Nectar Dispersion Patterns in a Population of *Impatiens capensis*

Michael Zimmerman

Department of Biology
Oberlin College
Oberlin, Ohio 44074

Abstract—An analysis of the nectar dispersion pattern of a population of *Impatiens capensis* demonstrated that patches of flowers with similar standing crops of nectar exist. The implications of this pattern on the foraging behavior of nectar feeding pollinators is discussed and it is predicted that pollinators should utilize an area restricted searching pattern. Such a foraging pattern would facilitate pollen dispersal by chasmogamous flowers.

Introduction

An integration of pollinator foraging behavior and plant reproductive strategies is critical if we are to fully understand the coevolutionary pressures impinging on the participants in these systems. Pollinators are under strong selection pressure to maximize their rate of net energy intake while foraging (cf. Pyke *et al.*, 1977) and plants are under similar pressure to maximize their reproductive output. Pollinator foraging behavior can be influenced by a number of plant characteristics which may vary between plant populations. For example, as interplant distances increase, pollinator flight distances also increase (Levin and Kerster, 1969a, b; Zimmerman, 1981b). As floral arrangement becomes more unpredictable (i.e., as large numbers of flowers are scattered over a plant instead of being packed onto a single inflorescence) pollinators stop incorporating a directionality component into the foraging strategy (Zimmerman, 1979a, b), and, in a number of plant species, the amount of reward received influences subsequent foraging movements (Pyke, 1978; Hartling and Plowright, 1979a, b; Pleasants and Zimmerman, 1979; Zimmerman, 1979a, 1981a, b). While there have been a great number of studies which have characterized the nectar production rates of plant species there have been relatively few studies which have attempted to describe the dispersion pattern of standing crop of nectar for a population (Pleasants and Zimmerman, 1979; Zimmerman, 1979a, 1981a, c). Examining nectar dispersion patterns is of interest because when patches of flowers with similar standing crops exist it has been predicted (Pyke, 1978; Pleasants and Zimmerman, 1979; Zimmerman, 1979a) that pollinators should forage utilizing an area-restricted searching behavior. Basically, this behavior consists of foragers reacting to nectar volumes encountered by having their interflower (or interplant) movement distances negatively correlated with the amount of reward received at a flower.

The coevolutionary implications of such a correlation are striking. Zimmerman (1981c) has shown that foragers utilizing an area-restricted searching behavior will actually create a patchy resource base and thus

reinforce such foraging. He has further demonstrated (Zimmerman, 1981a) that such a foraging strategy will increase the neighborhood size of the plant population by having pollen grains transported long distances after pollinators encounter flowers with little standing crop of nectar. An increase in neighborhood size can be of evolutionary significance to plants because, as Schaal (1980) has shown, in situations when pollinators move predominately between nearest neighbors, neighborhood size may be very restricted. Random events associated with small populations may thus be a dominant evolutionary force under such conditions. As neighborhood size increases random events play a much less significant role.

The present study characterizes the nectar dispersion pattern for a population of *Impatiens capensis* Meerb. (Balsaminaceae) and demonstrates that flowers with similar nectar volumes are often associated with one another, i.e., that nectar patches exist. This work is thus a preliminary step towards characterizing floral rewards and predicting pollinator behavior as well as seeing how widespread area restricted searching behavior is in plant/pollinator systems.

Methods

The fieldwork was conducted on 12 September 1980 utilizing a roadside population of *Impatiens capensis* located approximately 12.5 km west of the town of Oberlin, Ohio. *I. capensis* is an annual producing both chasmogamous and cleistogamous flowers (Schemske, 1978). The orange-colored chasmogamous flowers are approximately 16.4 mm long with an 8.3 mm nectar spur (Schemske, 1978) and are primarily pollinated by the bumblebee *Bombus vagrans* (Rust, 1977; Schemske, 1978).

Flowers, chosen at random, had their standing crop of nectar measured by slitting open the nectar spur and removing all available nectar with a 5 μ l capillary tube. The 162 flowers sampled in this manner were termed subject flowers. Standing crop of nectar was also measured for the two nearest neighbors of each of the subject flowers. Nearest neighbors were within 0.5 meters of subject flowers. In all, 486 flowers were sampled.

The mean nectar volume for all sampled flowers was calculated. This value was then used to distinguish between two classes of flowers: "cold" flowers had equal to or less than the mean while "hot" flowers had greater than that amount of nectar. A 2 \times 2 contingency table was then created. The cells of this table indicated

the frequency with which either a hot or a cold subject flower had either two cold nearest neighbors or at least one hot nearest neighbor. A Chi square test corrected for continuity was performed on the data to see if subject flowers and nearest neighbor flowers with similar nectar volumes were associated with one another. A second table using the median nectar volume of all sampled flowers to distinguish between hot and cold blossoms, was also created. Additionally, correlation coefficients were calculated for nectar volumes in subject flowers and first nearest neighbors as well as between subject flowers and second nearest neighbors.

Results and Discussion

The results of the nearest neighbor analysis are presented in Table 1. Both the mean and the median criteria yielded similar results. Both the mean and the median were chosen because although it is not clear exactly how pollinators go about assessing the quality of their environment it is reasonable to suspect that pollinators would use a relative rather than an absolute value as well as one that relates to the central tendency of the nectar distribution in question (Charnov, 1976; Zimmerman, 1981c). In both cases hot subject flowers were associated with hot nearest neighbors while cold subject flowers were associated with cold nearest neighbors. These results mean that nectar resources in *I. capensis* are patchily distributed and the amount of nectar found in one flower can be successfully used to predict the amount of nectar expected in a nearby flower. This predictability is further demonstrated by the correlation coefficients between nectar volumes in subject flowers and first and second nearest neighbors ($r = 0.432$, $P < 0.01$, $r = 0.374$, $P < 0.01$, respectively; $N = 162$).

Demonstrating a patchy nectar distribution in *I. capensis* is not equivalent to demonstrating the cause of that distribution. The dispersion pattern observed might be due to the foraging patterns of pollinators or due to the fact that nearest neighbor flowers were almost invariably on the same individual and therefore may have had similar nectar production rates. The cause of the pattern, for the moment however, is irrelevant. What is important is the effect that such a pattern will have on the subsequent foraging behavior of nectar feeding pollinators.

If one assumes, as do all models of optimal foraging, that pollinators forage in a manner which maximizes their rate of net energy intake (cf. Pyke *et al.* 1977) then nectar patches of the sort described in *I. capensis* should lead to a particular type of foraging behavior. Because the probability of encountering a hot flower near another hot flower is quite high, pollinators, after encountering one such flower, should next move to a near-by flower. Similarly, because the probability of encountering a hot flower near a cold flower is low, a pollinator, after encountering a cold flower, should move a greater distance and leave the cold patch. More specifically, patchiness in nectar should lead to area-restricted searching on the part of pollinators.

Area-restricted foraging has been reported in four studies of nectar feeding pollinators. Pyke (1978) demonstrated such behavior by *Bombus appositus* queens foraging on *Delphinium nelsonii* (Ranunculaceae), and *B. flavifrons* workers foraging on *Aconitum columbianum* (Ranunculaceae). *Bombus* spp. workers and queens utilize the same strategy when foraging for nectar on *Thermopsis montana* (Leguminosae) (Zimmerman 1981a) and Gill and Wolf (1977) have shown that sunbirds (*Nectarina* spp.) react to varying amount of nectar in *Leonotis nepetiflora* (Lamiaceae) in a similar manner. The underlying resource distribution was examined in the cases of *D. nelsonii* and *T. montana* and was found to be patchy in both cases (Pleasant and Zimmerman, 1979; Zimmerman, 1979a, 1981a,c). The present study, then, is only the third report on the nectar dispersion pattern of a plant population. In all three cases a patchily distributed resource base was found.

The pattern of nectar dispersion in *I. capensis* strongly suggests that optimally foraging bumblebees should be utilizing an area-restricted searching pattern. Confirmation of this prediction awaits detailed observations of bumblebees on this species.

It should also be noted that flower presentation on *I. capensis* is quite different than on the four above mentioned plant species. Flowers on *I. capensis* are produced singly and are scattered over the plant while the other four species produce relatively dense inflorescences. Since it has been shown that the method of flower presentation can influence some aspects of foraging behavior (Zimmerman, 1979a,b) it is interesting that the predicted optimal strategy on *I. capensis* is similar to that on the other species. These results at least suggest that area-restricted searching may be a very common strategy employed by pollinators.

Finally, the advantage to the plant of having pollinators utilize an area-restricted searching behavior can be discussed. *I. capensis* produces both chasmogamous and cleistogamous flowers. Since the cleistogamous flowers produce seeds in the absence of pollinators and at a lower energetic cost than do the chasmogamous flowers, it has been hypothesized (Schemske, 1978) that the chasmogamous flowers serve to increase outbreeding. Waller (1980) reports that chasmogamous flowers are produced on the periphery of the top branches making them both conspicuous and available to pollinators. Additionally, the fact that flowers remain in the male phase approximately five times longer than in the female state produces functional monoecy and thus probably promotes outcrossing as well (Schemske, 1978). The patches of nectar found in the present study can also be seen as an aid to outbreeding. The long moves associated with poor quality patches tend to increase neighborhood size (Zimmerman, 1981a) and thus increase pollen dispersal. This increased dispersal distance will lower the probability of geitonogamous fertilization occurring and promote greater genetic variability among the seeds of chasmogamous flowers relative to cleistogamous ones.

TABLE 1

Relationship between the reward value of subject flowers and their nearest neighbors. All flowers which had more nectar than the appropriate value for distinguishing between hot and cold flowers were considered hot while all others were considered cold (Mean = 0.55 μ l; Median = 0.40 μ l).

Value for Distinguishing Between Hot and Cold Flowers				
	Mean		Median	
SUBJECT FLOWERS				
	Hot	Cold	Hot	Cold
Two nearest neighbors:				
Hot and Hot or				
Hot and Cold	47	36	69	35
Cold and Cold	21	58	20	38
	$\chi^2 = 13.79$		$\chi^2 = 14.01$	
	$P < 0.0001$		$P < 0.0001$	

Acknowledgements

The fieldwork was performed by the students in the laboratory section of Biology 205 at Oberlin College. I thank them for their assistance. The manuscript was improved by comments from Abby Frucht.

Literature Cited

- Charnov, E. L. (1976): Optimal foraging: The marginal value theorem. *Theor. Pop. Biol.* 9: 129-136.
 Gill, F. B. and L. L. Wolf, (1977): Nonrandom foraging by sunbirds

- in a patchy environment. *Ecology* 58: 1284-1296.
 Hartling, L. K. and R. C. Plowright. (1979a): Foraging by bumblebees on patches of artificial flowers: a laboratory study. *Can. J. Zool.* 57: 1866-1870.
 _____. (1979b): An Investigation of inter- and intra-inflorescence visitation rates by bumblebees on red clover with special reference to seed set. *Proc. 14th Int. Symp. on Pollination* Md. Agric. Exp. Sta. Spec. Misc. Publ. 1: 457-460.
 Levin, D. A. and N. W. Kerster. (1969a): Density-dependent gene dispersal in *Liatris*. *Amer. Natur.* 103: 61-74.
 _____. (1969b): The dependence of bee-mediated pollen and gene dispersal upon plant density. *Evolution* 23: 560-571.
 Pleasants, J. M. and M. Zimmerman. (1979): Patchiness in the dispersion of nectar resources: Evidence for hot and cold spots. *Oecologia (Berl.)* 41: 283-288.
 Pyke, G. H. (1978): Optimal foraging: Movement patterns of bumblebees between inflorescences. *Theor. Pop. Biol.* 13: 72-98.
 _____. H. R. Pulliam and E. L. Charnov. (1977): Optimal foraging: A selective review of theory and tests. *Quart. Rev. Biol.* 52: 137-154.
 Rust, R. W. (1977): Pollination in *Impatiens capensis* and *Impatiens pallida* (Balsaminaceae). *Bull. Torrey Bot. Club* 104: 361-367.
 Schaal, B. A. (1980): Measurement of gene flow in *Lupinus texensis*. *Nature* 184: 450-451.
 Schemske, D. W. (1978): Evolution of reproductive characteristics in *Impatiens* (Balsaminaceae): The significance of cleistogamy and chasmogamy. *Ecology* 59: 596-613.
 Waller, D. M. (1980): Environmental determinants of outcrossing in *Impatiens capensis* (Balsaminaceae). *Evolution* 34: 747-761.
 Zimmerman, M. (1979a): An analysis of the reproductive strategies of *Polemonium* in Colorado. Ph.D. Dissertation. Washington University St. Louis, Missouri, U.S.A.
 _____. (1976b): Optimal foraging: A case for random movement. *Oecologia (Berl.)* 43: 261-267.
 _____. (1981a): The effect of nectar production on neighborhood size. *Oecologia (Berl.)*. In Press.
 _____. (1981b): Optimal foraging, plant density and the marginal value Theorem. *Oecologia (Berl.)* 49: 149-153.
 _____. (1981c): Patchiness in the dispersion of nectar resources: Probable causes. *Oecologia (Berl.)* 49: 154-157.

Dextroamphetamine Affects Hypothalamic-Pituitary-Thyroid Activity: A Preliminary Study

Melvin Ching

Department of Anatomy
Medical College of Virginia
Richmond, Virginia 23298

Abstract—The daily subcutaneous injection of 10 mg/kg BW d-amphetamine sulfate (AS) into both male and female rats over a three week period reduced the storage and secretion of thyrotropin (TSH) without affecting serum thyroxine (T_4) concentrations. Hypothalamic content of thyrotropin releasing hormone (TRH) was also depressed following AS treatment. Thus, it is hypothesized that the decline in pituitary thyrotrope activity during AS treatment resulted from a suppression of TRH synthesis and release from the endocrine hypothalamus.

Introduction

Amphetamines have been used as an appetite suppressant (Anderson, 1974; Sapeika, 1974; Innes & Nickerson, 1975; Valverde-R *et al.*, 1976) and CNS stimulant (Sapeika, 1974; Weiner, 1980; Valverde-R *et al.*, 1976) in humans. However, a review of the literature reveals little work has been done regarding the effect of this drug on hypothalamic-pituitary-thyroid activity (HPTA). Melander, *et al.* (1976) reported that euthyroid patients, treated with amphetamines because of mental illness, displayed significant elevation in blood titers of T_3 and T_4 without corresponding changes in pituitary TSH secretion. On the other hand, Valverde-R, *et al.*, (1976) claimed that amphetamine blunted the normal increases in TSH and the decreases in T_4 in the circulation of humans during sleep. Knigge (1974) reported that one hour of incubation with 1 mg/ml amphetamine virtually depleted the rat median eminence of TRH. The variations in these results are no doubt due in part to difference in experimental protocol. The present study was conducted to determine whether or not long term administration of d-amphetamine affects the HPTA in maturing laboratory rats.

Materials and Methods

Five-week-old Sprague-Dawley litter mates were either left intact or injected sc, daily, with 10mg/kg BW dextroamphetamine sulfate (AS) (Dexadrine, 5mg/tablet, lot 146-E19, Smith-Kline & French, dissolved in distilled water). The rats were fed Purina chow chex and maintained under controlled temperature ($22 \pm 1^\circ\text{C}$) and artificial lighting (lights on 0600 to 1800 hours). After three weeks the rats were decapitated and sera and extracts of anterior pituitaries and hypothalamus obtained as previously described (Ching, *et al.*, 1974, Knigge, *et al.*, 1974). Serum and pituitary concentrations of TSH and T_4 were quantified by radioimmunoassay in the manner previously reported

(Ching, *et al.*, 1974, 1975) whereas hypothalamic content of TRH was measured by bioassay (Knigge, *et al.*, 1974).

Results and Discussion

In terms of body weight equivalence, the daily dose of 10mg/kg AS is approximately 25 times the recommended oral dose for humans (Weiner, 1980). Nevertheless, various studies have been performed in rats in which doses as high as 20 - 64mg/kg/day for 2 - 4 weeks, were used (Tormey & Lasagna, 1960; Lewander, 1971). However, these studies were mainly concerned with the effects of amphetamines on self stimulation behavior, appetite suppression and changes in body weight, alterations in body temperature, locomotor activity, stereotypic behavior, etc. and not with the hormonal effects relating to thyroid activity.

In the present study, the daily injections of AS to male and female rats for 3 weeks caused reductions in both the serum and pituitary concentrations of TSH and in the hypothalamic stores of TRH (Table I). Serum T_4 titers and thyroid weight and growth, as indicated by the gain in body weights remained unchanged from normal following chronic AS treatment.

The decreased levels of serum TSH observed in the AS-treated rats were not attributable to an enhancement of the negative feedback by T_4 since the latter's concentration in blood were not increased over normal. Averill (1969) has reported that full suppression of the pituitary response to TRH might require pre-treatment with supranormal doses of T_4 . Although TRH release rates were not assessed in the present study, the reduction in bioassayable TRH contained within the hypothalamus, coupled with the decrease in the storage and secretion of pituitary TSH, suggest that AS treatment caused a decline in hypothalamic TRH synthesis and/or secretion.

It should be mentioned that Vale, *et al.* (1974) reported that 2-10ug somatostatin (SRIF) reduced the TRH-induced pituitary secretion of TSH in mice prepared for TRH bioassay. Thus, this quantity of SRIF, if present in the hypothalamic extracts of AS-treated rats, could account for the reduction in the bioassayable TRH content. However, recent studies in our laboratory revealed that the hypothalamus-median eminence complex of normal and drug-treated two-month-old male and female SD rats contained 200-

1300 pg radioimmunoassayable SRIF (unpublished observation). Higher concentrations of SRIF have been reported by other investigators (Brownstein, *et al.* 1975; Patel & Reichlin, 1978). However, even at the hypothalamic contents of 39-77ng SRIF reported by these groups, less than 213 ng SRIF would have been administered to the bioassay recipients which is approximately one-tenth the minimal effective dose of SRIF required to inhibit the pituitary secretion of TSH.

Thus, all things considered, the available results do

not support the notion that amphetamine increases the secretion of TRH as previously reported by Knigge (1974). If amphetamine did increase the secretion of TRH this could account for the lower TRH stores but would also introduce the possibility that the drug blocked the TRH-induced release of TSH. In an effort to clarify this controversy, attempts will be made to quantitate hypothalamic TRH secretion into hypophyseal portal blood of the AS-treated rat in the manner previously reported (Ching & Utiger, 1980).

TABLE I

Body and thyroid weights, and storage or serum concentrations of TSH, T₄ and TRH in male and female rats treated with d-amphetamine sulfate as compared to normal controls. Data represent means±SEM. Cerebral cortex control tissue contained no detectable TRH.

Group	Sex	No.	BW (g)	TW (mg)	TSH Serum (mU/dl)	TSH Pituitary (mU/mg)	T ₄ Serum (ug/dl)	TRH Hypothal. (ng)
NC	M	9	262±15	17.9±1.6	14±4	14.9±1.9	5.5±0.6	2.6±0.1
AS	M	7	257±12	16.5±1.7	3±1*	6.3±1.9+	5.3±0.6	1.0±0.2+
NC	F	9	199±5	16.1±1.6	13±3	13.1±1.3	4.5±0.7	2.4±0.3
AS	F	7	192±4	15.4±0.7	3±1*	9.9±2.9	—	1.3±0.3#

Significance from NC: # p<0.05; * p<0.02; + p<0.01

Acknowledgements

This work was supported in part by a grant from the Human Growth Foundation, Minneapolis, Minnesota and grant HD 12276 from the National Institutes of Health, Bethesda, Maryland.

References

- Anderson, J. (1974). Drugs and appetite. *Practitioner* 212, 536-544.
- Averill, R. L. W. (1969). Depression of thyrotropin releasing factor induction of thyrotropin release by thyroxine in small doses. *Endocrinology* 85: 67-71.
- Brownstein, M., Arimura, A., Sato, H., Schally, A. V., & Kizer, J. S. (1975). The regional distribution of somatostatin in the rat brain. *Endocrinology* 96: 1456-1461.
- Ching, M., Evans, A. B., Evans, E. S., Joseph, S., & Sorrentino, S. Jr. (1974). Pituitary thyrotroph function in hypothyroid rats. *Acta Endocrinol. (khh)* 75: 221-232.
- Ching, M. C. H., Schalch, D. S., & Lebeda, N. J. A. (1975). Role of growth hormone in the enhancement of the propylthiouracil-induced goitrogenesis by small doses of thyroxine. *Acta Endocrinol. (khh)* 79: 238-247.
- Ching, M. & Utiger, R. D. (1980). Can thyroidectomy or thyroid hormone therapy elicit changes in pituitary stalk blood TRH concentrations? *Endocrinology* 106 (Suppl.): 234 (Abstract).
- Knigge, K. M. (1974). Role of the Ventricular system in neuroendocrine processes. Initial studies on the role of catecholamines in transport of thyrotropin releasing factor. In *Front. Neurol. Neurosci. Res.*, pp. 40-47. Eds. P. Sceman & G. M. Brown. Toronto: Univ. Toronto Press.
- Knigge, K. M., Joseph, S. A., Schock, D., Silverman, A. J., Ching, M. C. H., Scott, D. E., Zeman, D., & Krobish-Dudley, G. (1974). Role of the ventricular system in neuroendocrine processes: synthesis and distribution of thyrotropin releasing factor (TRF) in the hypothalamus and third ventricle. *Canad. J. Neurol. Sci.* 1: 74-84.
- Lewander, T. (1971). A mechanism for the development of tolerance to amphetamine in rats. *Psychopharmacologia* 21: 17-31.
- Melander, A., Bulow, K., Burger, A., Ericson, I. E., Ingemansson, S., Ljunggren, J.-G., Norberg, K.-A., Persson, B., Sundqvist, S.-B., Sundler, F., Tibblen, S., & Westgren, U. (1976). Influence of the sympathetic nervous system on thyroid activity in man. In *Thyroid Research*, pp. 100-102. Eds. J. Robbins & I. E. Braverman. Amsterdam: Excerpta Medica.
- Patel, Y. C. & Reichlin, S. (1978). Somatostatin in hypothalamus, extrahypothalamic brain, and peripheral tissues of the rat. *Endocrinology* 102: 523-530.
- Sapeika, N. (1974). Drugs in obesity. *S. Afr. Med. J.* 48:2027-2030.
- Tormey, J. & Lasagna, L. (1960). Relation of thyroid function to acute and chronic effects of amphetamine in the rat. *J. Pharmacol. Exp. Ther.* 128: 201-209.
- Vale, W., Rivier, C., Brazeau, P., & Guillemin, R. (1974). Effects of somatostatin on the secretion of thyrotropin and prolactin. *Endocrinology* 95: 968-977.
- Valverde-R.C., Pastrana, I. S., Ruiz, J. A., Solis, H., Jurado, J. I., Sordo, C. M., Fernandez-Guardiola, A. & Maisterrena, J. A. (1976). Neuroendocrine and electroencephalographic sleep changes due to acute amphetamine ingestion in human beings. *Neuroendocrinology* 22: 57-71.
- Weiner, N. (1980). Norepinephrine, Epinephrine, and the sympathomimetic amines. In *The Pharmacological Basis of Therapeutics*, Chapter 8, pp. 138-175. Eds. A. G. Gilman, L. S. Goodman & A. Gilman. New York: MacMillan Co., Inc.

Inactivation of Poliovirus-2 in Natural Waters: A Thermolabile Factor¹

James C. Johnson²

Division of Microbiology
University of Osteopathic
Medicine and Surgery
3200 Grand Ave.
Des Moines, Iowa 50312

Patrick G. Haggerty, Margaret J. Roberts, and Robert P. Olson

Department of Biology Sciences
Old Dominion University
Norfolk, Virginia 23508

Abstract—The inactivation of poliovirus-2, strain W-2, in filter sterilized surface ocean water was found to be biphasic at 17°C with the initial rate 7-fold greater than the secondary inactivation rate. These rates were greater than that for deionized water and less than for an artificial seawater with higher pH and salinity. By increasing the pH and/or salinity of ocean water to that of the artificial seawater, the inactivation rate increased. Autoclaving filter sterilized ocean water resulted in the loss of a virus inactivation component and prolonged inactivation kinetics. Capsid polypeptide alterations were detected by polyacrylamide gel electrophoresis following long incubations of virus in filter sterilized ocean water but not in autoclaved ocean or deionized waters. An inactivation component in filter sterilized ocean water was concentrated by thin channel ultrafiltration. The concentrated activity increased the rate of Po-2 inactivation 20-fold, was heat sensitive, nondialyzable, and inactivated at pH below 3.2 and above 11.0. The presence of protein in the concentrate was confirmed by gel electrophoresis and protein analyses.

Introduction

Human enteric viruses are produced in large numbers and become associated with wastewaters from which they may be readily isolated. More than a hundred serotypes predominately members of the picornaviridae (polioviruses, coxsackieviruses, and echoviruses) as well as the adenoviridae, reoviridae and less well characterized gastroenteritis viruses, the rotaviruses, and the causative agent of infectious hepatitis are known to frequent wastewaters and are thought to be transmitted by means of the water route (Melnick, 1978). As a consequence of wastewater treatment procedures designed predominately for the reduction of fecal coliform numbers and not enteric and related viruses, viral infectious agents may readily be detected and isolated from outflows and in receiving waters downstream from outflows (Berg, 1973).

The fate of viruses in the aqueous environment is subject to numerous variables. Evaporative processes associated with bubble ejection or aerosols are virucidal (Ward and Ashley, 1977). Ultraviolet irradiation and thermal effects contribute to virus inactivation (Akin et al., 1971). Particle adsorptive phenomenon (electrostatic interactions-trapping) contribute to the removal of virus from water by transfer to the sediment. In laboratory studies the proteolytic activities emanating from several genera of bacteria are responsible for virus inactivation (Cliver and Herrmann, 1972). The relative significance of each of these is not known for any environmental situation.

Experiments conducted in natural fresh waters using laboratory strains of purified viruses indicate that virus inactivation rates are predictable as a direct function of the temperature (O'Brian and Newman, 1977). Irreversible inactivation of virus is accompanied by damage to the viral RNA. Since the viral capsid surrounds or contains the viral nucleic acid, it has been suggested that two temperature dependent processes may be involved in the inactivation of single stranded RNA viruses. The first is a modification in the capsid structure exposing the nucleic acid to the environment, and the second is a cleavage event serving the phosphodiester linkage of the viral RNA. (Ward and Ashley, 1976; O'Brian and Newman, 1977).

The report describes the inactivation of the single stranded RNA virus, poliovirus-2, in filter sterilized marine surface waters obtained from the shorelines of beaches and recreational waters in the Tidewater area of Southeastern Virginia.

Materials and Methods

Cells and Virus Propagation. Poliovirus, type 2, strain W-2 (hereafter designated Po2), obtained from the American Type Culture Collection, (VR-301) was plaque purified and utilized in all experiments. African green monkey kidney cells (AGMK; American Type Culture Collection certified cell line 7.1) were cultured in an autoclavable minimal essential medium (Flow Laboratories, Inc.) containing 10% fetal calf serum and antibiotics (penicillin and streptomycin). Cells were incubated at 37°C in an atmosphere containing 5% CO₂ and 95% relative humidity. The stock of poliovirus was prepared from a lysate of AGMK cell monolayers infected with a multiplicity of infection (m.o.i.) of about 1 particle per cell. The growth media, cells, and cell debris from the Po-2 infection were rapidly frozen at -60°C and thawed 3 times. The lysate was centrifuged at 15,000 xg for 10 min at 4°C. The supernatant containing the virus was centrifuged for 2.5

Footnotes

¹Communication No. 3-101 from the Laboratory of Environmental Virology, Old Dominion University.

²To whom to address all correspondence. This study has been supported in part by grant No. A-086-Va. from the Virginia Water Resources Research Commission.

hours at 40,000 rpm in a 60-Ti Beckman rotor at 4°C. The resulting pellet was resuspended in tryptose phosphate broth (Gibco) and sonified using a Bronson Model 6 ultrasonifier. The suspension was passed through a 0.22 micron filter and adjusted to a titer of about 2×10^7 pfu/ml.

Poliovirus Plaque Assay. AGMK cells were grown to confluence in Falcon tissue culture dishes (20 cm²). Serial dilutions of samples were made in Earle's balanced salt solution (EBSS; Flow Laboratories, Inc.) containing 2% fetal calf serum and aliquots were added to EBSS-washed confluent cultures. The adsorption volume was 0.4 ml and the plates were incubated with agitation at 15 min intervals during a 75 min adsorption period. Following adsorption, the inoculum was removed and the cells overlaid with complete growth medium containing 1.5% Bacto agar (Difco). Plaques were counted after 75 hours with the aid of neutral red staining of vital cells.

The linearity of the dose response curves was determined for Po-2 suspended in each of the selected waters. A linear dose response curve was obtained for each sample up to 40 plaques per plate. All viral titers were calculated from the slope of the linear region of the dose response curve.

Water Collection Sites. Grab samples (2 liters) of surface waters were obtained from the Atlantic Ocean surf at a beach 500 m to the North of Rudee Inlet in Virginia Beach. Deionized water was obtained from an 18 megohm resistance continental deionizing system. A Pall ultipore 0.22 μ filter was in line with the outflow. Artificial sea water was prepared from Instant Ocean salts and was found to have an unadjusted pH of 9.1. All water samples were stored at 4°C in sterile glass containers and passed through prewashed 0.45 micron membrane (Nalgene) filters. Samples of these waters were analyzed for chemical content or inoculated with poliovirus within 2 days after collection.

Chemical Analysis of the Filter-Sterilized Waters. The hydrogen ion concentration in each of the filtered water samples was determined using a Corning pH meter with a calibrated hydrogen ion electrode. The salinity of the samples was determined using an American Optical refractometer or conductivity meter.

Purification of Radiolabeled Poliovirus. ¹⁴C-labeled poliovirus was prepared by a modification of the procedures described by Ward and Ashley (1976). Confluent AGMK cultures in 150 mm Falcon petri dishes were washed three times with EBSS and incubated at 37°C in EBSS for an additional 2 hours. The EBSS was removed and 4.0 ml of labeling medium (95% EBSS, 4.5% autoclavable MEM (minimum essential medium; Flow Labs), 0.5% dialyzed fetal calf serum and 17 mCi/ml of a uniformly labeled ¹⁴C-algal protein hydrolysate (specific activity 100 Ci/mole) (New England Nuclear Corp.) was added. Poliovirus-2 was then added at a m.o.i. of greater than 3.0 pfu/cell and incubated for one hour. An additional 4.0 ml of labeling medium minus ¹⁴C-amino acids was added to each plate. The plates were incubated for 20 hours or until complete cell lysis occurred. The media and cell

debris were collected and 3 times frozen and thawed. The mixture was centrifuged at 10,000 xg for 10 min and the supernatant fraction centrifuged in a Beckman 60-Ti rotor at 40,000 rpm for 2.5 hours. The pellet which contained most of the virus was resuspended in 1.0 ml of phosphate buffered saline (PBS; Gibco). The suspension was sonicated then mixed with an equal volume of n-butanol and shaken vigorously. The phases were separated by centrifugation at 100 xg for 10 min at 4°C. The butanol phase was removed by aspiration and the aqueous phase was re-extracted twice more with n-butanol. The butanol phases were pooled and extracted with 5 ml of PBS. All aqueous phases were combined (6.5 ml) and applied to a 10 to 30% w/w linear sucrose gradient (32 ml) in PBS. The gradients were centrifuged for 2.5 hours at 26,000 rpm in a SW-27 rotor at 4°C. Fractions (1.0 ml) were collected and monitored for radioactivity. Fractions containing the majority of radioactivity and with sedimentation coefficients between 150 to 160 S as determined by the method of McEwen (1967) were pooled, dialyzed against phosphate buffered saline, titered, and stored at -20°C.

Polycrylamide Gel Electrophoresis. Poliovirus capsid proteins were separated by sodium dodecyl sulfate (SDS) polycrylamide gel electrophoresis according to the procedure described by Baum et al. (1972). Radiolabeled poliovirus proteins and standard molecular weight marker proteins were placed in the adjoining wells of 10% acrylamide slab gels and run for 3 hours at 20 ml or unit the phenol red marker moved to the end of the gel. The gels were stained overnight in Coomassie brilliant blue, then destained in a solution of acetic acid (10%) and methanol (40%). The lanes containing radioactivity were cut into 1 mm sections. Each section was hydrolyzed in hydrogen peroxide then analyzed for radioactive content according to the procedure of Gerard et al. (1972).

Samples of ¹⁴C-Po-2 from each virus inactivation experiment were made to 10% in trichloroacetic acid, incubated for 30 min on ice, then collected by centrifugation at 33,000 xg for 30 min at 4°C. The supernatants were discarded and the pellets washed twice with cold acetone and once with ether. Each washing was followed by centrifugation at 35,000 xg for 20 min at 4°C. These acid precipitated and washed samples were applied to gels for analysis of polypeptide content.

¹²⁵I-BSA samples from incubation studies did not require concentration and were applied to the lanes of gels directly.

Radiiodonation of BSA. Bovine serum albumin, fraction V, was labeled with ¹²⁵I according to the procedure of Hunter (1967). The labeled protein was stored at -20°C until use.

Results

Inactivation of Poliovirus-2 in filter sterilized waters. The inactivation kinetics at 17°C of Po-2 in filter sterilized and/or autoclaved, filtered sterilized ocean, deionized or artificial seawater is presented in Figure 1. The initial rate of inactivation of Po-2 in filter sterilized

artificial seawater was about seven times as rapid as that for deionized water and about the same as found for ocean water (Figure 1A). The inactivation was apparently biphasic in ocean water. Whereas 3 to 4 days were required to inactivate half of the virus during the initial rate of Po-2 inactivation, 14 to 22 days were required during the second phase of inactivation. Approximately 70 to 90% of the total infectivity was inactivated during processes involved in the initial

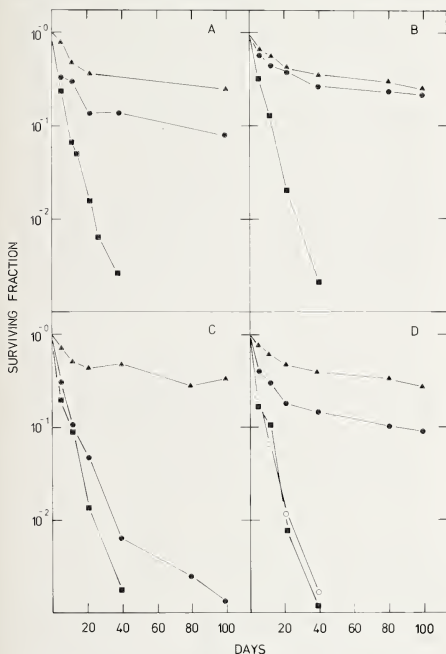


FIG 1—Poliovirus-2 inactivation in autoclaved and/or filter sterilized water. Samples of each water, ocean, artificial sea water, or deionized, were inoculated at 2.2×10^5 pfu/ml from a stock of virus at 2.2×10^7 pfu/ml. The inocula, in sterile screw cap, polypropylene tubes were incubated at $17^\circ\text{C} \pm 0.2$ in darkness for the indicated times until virus assay.

Panel A. Virus inactivation in filtered water. \blacktriangle — \blacktriangle , deionized water, pH 6.9, 0.00 parts per thousand (ppt) as salinity; \bullet — \bullet , surface ocean water, pH 8.2, salinity 19.5 ppt; \blacksquare — \blacksquare , artificial seawater, pH 9.1, salinity 31.0 ppt.

Panel B. Inactivation in autoclaved, filtered water. All symbols as in Panel A, each water sample was autoclaved.

Panel C. Inactivation in pH adjusted ocean water. Ocean water was filtered, autoclaved, and pH adjusted to 9.1 with sterile NaOH. Artificial seawater and deionized water were autoclaved and filtered. Symbols are as in Panel A.

Panel D. Inactivation in pH and salinity adjusted ocean water. Autoclaved, pH adjusted ocean water (pH 9.1) as in Panel C was made 31.0 ppt in salinity using an autoclaved, filtered stock of artificial seawater. Autoclaved symbols as in Panel A. \circ — \circ , pH and salinity adjusted ocean water.

rapid inactivation phase, the remainder during the second phase. After 102 days of incubation, over 25% of the input Po-2 plaque forming units (pfu) survived in deionized water, and about 8% of the input virus survived in ocean water. No viable Po-2 infectivity was detected after 60 days of incubation in artificial sea water. At 222 days (not shown) virus infectivity was found in deionized water (0.72%) but not in ocean water.

A significant reduction of Po-2 inactivation occurred in autoclaved, filter sterilized ocean water (Figure 1B). This change amounted to a 5-fold decrease in the measured initial rate when compared to filter sterilized ocean water. The secondary rate for Po-2 in ocean water was the same as for deionized water. The inactivation rates for the autoclaved artificial sea and deionized waters (Figure 1B) were not significantly different from those of the respective, non-autoclaved waters (Figure 1A).

By adjusting the pH of autoclaved, filtered ocean water to that of the artificial seawater (pH 9.1) the rate of inactivation increased nearly to that for artificial seawater (Figure 1C). By adjusting both the pH and salinity the inactivation of Po-2 in autoclaved, filtered ocean water was found not to differ from that of artificial seawater (Figure 1D). The apparent result of these experiments was that both a relatively high pH and salinity contribute to Po-2 inactivation while heating filter sterilized ocean water contributes to a reduction of inactivation.

A possibility exists that some factor in the water samples could interfere with the plaque assay by inhibiting plaque formation. In order to examine this possibility, a control experiment was designed to test for the presence of plaque assay interfering materials in each of the water samples. Plaque assay plates were each

TABLE I
Effect of Filtered Water Samples on Plaque Formation

Preinoculation medium ^a	Plaque Formation (\log_{10} pfu/ml)
Cel culture media ^b	3.90
Deionized water	3.93
Artificial seawater	3.90
Atlantic Ocean water	3.76
Atlantic Ocean water (autoclaved)	3.71
No preincubation	3.79

^aStandard poliovirus plaque assays were performed using a 6.5×10^3 pfu/ml stock of virus of confluent 60 mm dishes containing AGMK cells. Culture media was separated and the cell sheet washed once with 2.0 ml of the respective 0.45μ filtered preinoculation medium. The dishes were incubated 75 min with 0.4 ml of preinoculation medium, the media removed by aspiration, and 0.4 ml of a poliovirus dilution in 2% fetal calf serum and EBSS added. After a 75 min adsorption period, the inoculum was removed and replaced by complete growth medium containing 1.5% agar. Plaques were counted at 3 days.

^bEagles modified minimal essential medium containing 10% v/v fetal calf serum.

mock infected for 1 hr with one of the filtered water samples in the absence of added Po-2. The mock infected places together with other assay plates were then exposed to a known amount of Po-2 in a standard plaque assay (Table 1). With the close agreement of the controls and experimental virus titers, inhibitor-mediated plaque reduction was either reversible over the span of the experiment or was not present.

Because of the adsorptive behavior of polioviruses, container interactions were studied for the possible removal of infectious Po-2 from the water. Polypropylene centrifuge tubes each containing one of the 0.45 micron filtered waters were seeded with 1×10^3 cpm/ml of a highly purified, ^{14}C -labeled Po-2 stock and incubated at 17°C for 1.0 hr or 14 days. The contents of each tube were assayed for radioactivity following incubation. The walls of the tubes were subsequently rinsed with 0.01 M Tris-HCl, pH 9.0, containing 0.1% sodium dodecyl sulfate. This procedure was found to desorb picornaviruses from container walls (J.C. Johnson, unreported observation). For each water sample, between 76.0% (deionized water) and 98.3% (ocean water) of the input radioactivity was found in the aqueous fraction, (Table 2). Virtually all of the radioactivity unaccounted for in the aqueous phase was recovered in the SDS wash of each tube.

Proteolytic activity in filtered ocean water. Because the virus inactivation property was itself heat sensitive, we suspected either inactivation or inhibition by a heat-formed inhibitor. The activity was not inactivated during autoclaving because of the formation of some inhibitor. The addition of equal parts of autoclaved, filtered ocean water to filtered ocean water resulted in a Po-2 inactivation similar to the rate and extent of the virus in filter sterilized ocean water.

TABLE 2
Poliovirus-2 Container Interactions^a

Water Source	Total Radioactivity Recovered		
	Aqueous Fraction		SDS Wash
	1.0 hour	14 days	14 days
	(cpm)	(cpm)	(cpm)
Deionized water	875 (77.4) ^b	859 (76.0)	228 (20.2)
Artificial seawater	982 (86.9)	1013 (89.6)	98 (8.6)
Atlantic Ocean water	1111 (98.3)	1010 (89.4)	41 (3.6)
Atlantic Ocean (autoclaved)	1099 (97.3)	1010 (89.4)	52 (4.6)

^a ^{14}C -poliovirus-2 (6.0×10^3 pfu cpm) ($40 \mu\text{l}$) containing 1130 cpm was mixed with 5.0 ml of each respective 0.45μ filtered water source in sterile Corning 50.0 ml of each respective 0.45μ filtered water source in sterile Corning 50.0 ml screw capped conical polypropylene tubes and incubated for the indicated times at 17°C . Following incubation for 1.0 hour or 14 days, duplicate 1.0 ml samples were counted in PCS (Amersham Inc.) using the automatic quench correction mode of a Beckman liquid scintillation spectrometer. After 14 days the remainder of the tube contents was discarded, the tube rinsed with 0.01 M Tris-HCl, pH 9.0 containing 9.1% SDS (1.0 ml), and the wash assayed for radioactivity.

^bNumbers in parenthesis refer to the percent of the cpm recovered relative to the total radioactivity added.

Hydrolytic polypeptide cleavages by activities present in the water may be responsible for virus inactivations. We used an assay for proteolysis which measured the change in pattern and motility of a ^{125}I labeled, highly purified bovine serum albumin on polyacrylamide gels in the presence of SDS.

The incubation of filtered ocean water with ^{125}I -BSA for 25 days at 17°C resulted in the hydrolysis of nearly half of the total protein (49%) (Figure 2A). Most of the hydrolysis products were found as discrete entities. The major breakdown products were found at apparent mol wts 62,000, 55,000, 38,000, 29,000, 15,000, and about 10,000. A control in which labeled BSA was incubated 25 days in the absence of added ocean water demonstrated that the labeled BSA did not undergo extensive self-hydrolysis or radiation induced breakdown (Figure 2B). Only 6.7% of the total amount of radioactivity was found in regions other than that for BSA. Of this 6.7% the major bands were at the gel top and at about mol wt 62,000. Incubation of the ^{125}I -BSA in autoclaved, filter sterilized ocean water resulted in a pattern unlike that for unautoclaved ocean water. The amount of label in the major component (91.2%) was similar to the incubated control (93.3%), (Figure 2C). These data support the hypothesis of the presence of hydrolytic activities, possibly enzymatic in nature, in ocean water.

Since enzyme mediated proteolytic activities are generally substrate specific, the ideal substrate for the study of poliovirus inactivation necessarily is a highly purified, radiolabeled poliovirus. Accordingly, a stock of ^{14}C -labeled Po-2 was used in studies of proteolytic

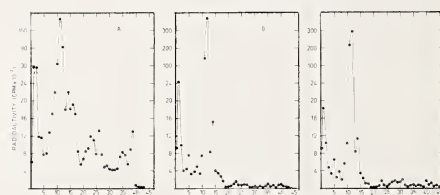


FIG. 2. Sodium dodecyl sulfate polyacrylamide gel electrophoresis of ^{125}I -BSA. BSA, fraction V, freshly labeled with ^{125}I according to the procedure of Hunter (1967) and with specific radioactivity of 3.9×10^5 cpm/ μg was incubated at 17°C for 25 days in total darkness in a reaction mixture containing $0.38 \mu\text{g}$ ^{125}I -BSA and either 0.45μ filtered Atlantic Ocean water ($80 \mu\text{l}$) filtered deionized water ($40 \mu\text{l}$), or autoclaved, filtered Atlantic Ocean water ($80 \mu\text{l}$). After incubation, a sample of each mixture ($40 \mu\text{l}$) was mixed with $10 \mu\text{l}$ of a 5-fold concentrated sample denaturation mixture (0.31 M Tris-HCl pH 6.8; 10% v/v SDS; 37.5% v/v glycerol; and 25% v/v 2-mercaptoethanol) heated to 100°C for 1 min, cooled, and injected into the sample wells of a 10% polyacrylamide slab gel. Electrophoresis was for 3.0 hours at 20 ma. The gel was stained with coomassie brilliant blue to visualize marker proteins then cut into 2.0 mm sections. Each section was analyzed for radioactivity by liquid scintillation spectrometry.

Panel A. ^{125}I -BSA incubated in filtered ocean water. Panel B. ^{125}I -BSA incubated in deionized water; Panel C. ^{125}I -BSA in autoclaved, filtered ocean water.

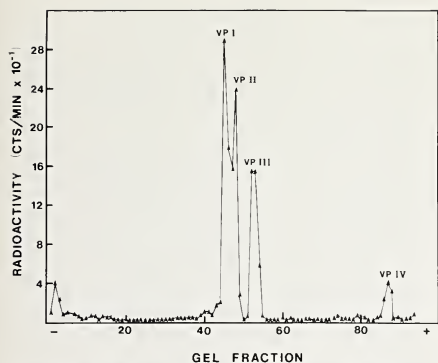


FIG. 3 Sodium dodecyl sulfate polyacrylamide gel electrophoresis of poliovirus-2. ^{14}C -labeled and purified poliovirus-2 (6×10^3 pfu/cpm), 2.1×10^3 cpm, was heat denatured and applied to a sample well of a 10% polyacrylamide slab gel containing 0.1% SDS according to the procedure described by Baum et al. (1972). Electrophoresis was for 3 hours at 20 ma. The gel was stained with Coomassie brilliant blue to visualize marker proteins and sectioned into 1.0 mm pieces using a mechanical fractionator. The pieces were analyzed for radioactivity content according to the procedure of Gerard et al. (1972). Recovery of ^{14}C -labeled material was 82%. The molecular weight marker proteins (in adjacent wells) were phosphorylase, bovine serum albumin, aldolase, ribonuclease I, and cytochrome C.

activity. The molecular weights of the four polypeptides (VP1-35,000; VP2-28,000; VP3-23,000; VP4-7,000) and the molar ratio of polypeptides (1.0, 1.0, 1.0, 0.8, respectively) was the same as found by Maizel (1971) (Figure 3). The total amount of label found in regions other than those of the four Po-2 component polypeptides was about 2%.

Labeled Po-2 was incubated for 32 days at 17°C in total darkness in either autoclaved-filtered deionized water, autoclaved-filtered ocean water, filtered ocean water, or without further dilution. SDS polyacrylamide gel analysis of the virus after incubation in the filtered ocean water revealed that nearly all of the radioactivity was in molecular species smaller than VP1, VP2, or VP3 (Figure 4B). Most of the ^{14}C -labeled material was found in material near VP4 or at the phenol red front in the gel. About 74% of the radioactivity migrated with the low mol wt components. A small amount of protein degradation was detected in autoclaved-filtered ocean water (Figure 4C). In this water there was an increased amount of material near the region of VP4. The molar ratio of the four peaks of radioactivity at the indicated mol wts for VP1, VP2, VP3 and VP4 was 1.0:1.0:0.9:2.3, respectively. Thus, it is not likely that all of the material found in the region of VP4 was virus-specific VP4. Protein degradation was not evident following incubation of Po-2 in autoclaved-filtered deionized water and the molar ratio of polypeptides was 1.0:1.0:0.9:1.0, respectively, (Figure 4D). To insure that the purified virus did not contain activities responsible for its own proteolysis, labeled Po-2 was incubated for 32 days at 17°C in the

absence of added water (Figure 4A). Little degradation was apparent (molar ratio of polypeptides 1.0:1.0:0.9:0.9) in comparison to Figure 3 indicating that the purified virus was free of significant amounts of active enzymes with any Po-2 polypeptide substrate specificities.

To insure that the test waters were and remained sterile throughout the ^{14}C -Po-2 incubation experiments, samples of each water tested for proteolytic activity were plated at the beginning and after 32d onto trypticase soy agar, seawater agar, and blood agar plates. The plates were incubated at either 15°C or 37°C for a total of 5 days with daily observations. None of the plates showed colony development or were otherwise positive for microorganisms.

Because the rate of inactivation of Po-2 in filtered ocean water was slow, potentially enzyme mediated, and thus difficultly studied, we began to search for methods for isolation and concentration of the activity. Evaporation and pervaporation methods at reduced

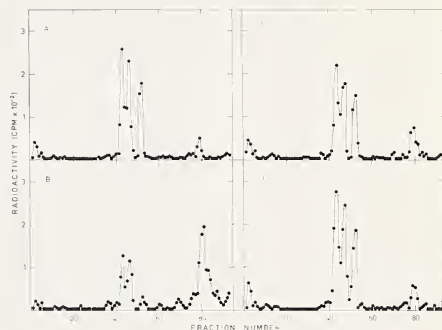


FIG. 4—Sodium dodecyl sulfate polyacrylamide gel electrophoresis of ^{14}C -poliovirus-2. ^{14}C -poliovirus-2 (3.9×10^3 cpm/pfu) purified as described in *Materials and Methods* was incubated in reaction mixtures containing 1.2×10^3 pfu (3.2×10^3 cpm, 0.3 ml) and 5.0 ml of either 0.45 μ filtered ocean water, panel B; autoclaved-0.45 μ filtered ocean water, panel C; or autoclaved-0.45 μ filtered deionized water, panel D. The electrophoretic pattern of ^{14}C -poliovirus-2 incubated without dilution into water is presented in panel A. Incubation was for 32 days at 17°C in darkness in sealed tubes. Following incubation, 4.0 ml samples of each mixture were mixed with 10% trichloroacetic acid and 40 μ g of carrier BSA was added. The mixtures were incubated for 1 hr on ice, then centrifuged at 20,000 rpm in a Beckman JA-21 rotor for 30 min at 4°C . The insoluble material was washed in 2.0 ml volumes of cold acetone and ether followed by collection by centrifugation. The acetone-ether washed pellet was dissolved in 80 μ l of the SDS polyacrylamide gel electrophoresis sample buffer (0.062 M Tris-HCl, pH 6.8, 2% w/v SDS, 7.5% v/v glycerol, and 5% v/v 2-mercaptoethanol). The radioactive samples together with molecular weight marker protein were heated to 100°C for 1 min then applied to a 10% polyacrylamide gel containing 0.1% SDS. Electrophoresis was performed as described in Figure 3. Following electrophoresis, the lanes containing radioactivity were sectioned into 1.0 mm pieces and analyzed for radioactivity (Gerard et al. 1972). Recoveries following electrophoresis were as follows: Panel A, 52.5%; Panel B, 78.4%; Panel C, 72.2%; Panel D, 85.3%.

temperatures resulted in total loss of the activity. Salting out procedures were found ineffective. The activity was, however, retained but not concentrated after dialysis of filtered ocean water in 12,000 molecular weight cutoff dialysis membrane versus autoclaved, filtered ocean water. Thin channel ultrafiltration at 4°C provided a means for an effective concentration. An 80-fold concentration resulted in a 22-fold increase in rate of inactivation. The inactivation curve was less biphasic in nature (Figure 5). The concentrated activity was found to be heat sensitive, nondialyzable, and inactivated when adjusted to pH 3.2 and/or 11.0 for 30 min followed by return to pH 8.4. The presence of proteins in this concentrated material has been confirmed by polyacrylamide gel electrophoresis in the presence of SDS. In preliminary studies we have observed approximately 7 to 9 distinct, Coomassie brilliant blue R stainable bands on SDS gels. Current studies are directed at the identification and characterization of hydrolytic activities among these proteins.

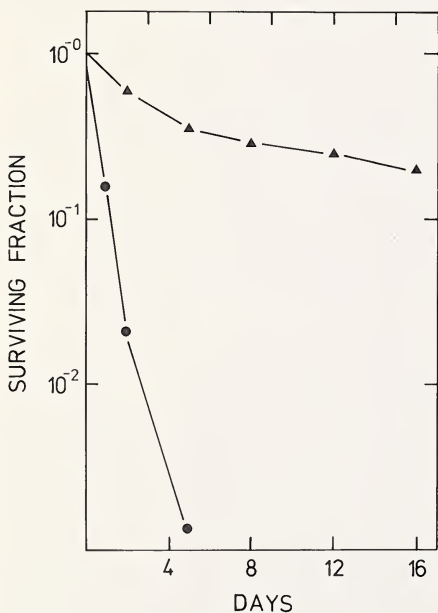


FIG. 5 Inactivation kinetics of poliovirus-2 following concentration. A 2 L sample of 0.45 μ filter sterilized ocean water was passed through a sterilized Amicon thin channel ultrafiltration apparatus containing a PM-10 membrane at the rate of 2 ml cm^{-2} min at 5°C. The concentrate (25 ml) and filter sterilized ocean water were inoculated with Po-2 at 4.0×10^4 pfu/ml under the conditions in Figure 1. Samples were taken at the indicated times for virus assay. Δ — Δ , filtered ocean water; \bullet — \bullet , ultrafiltration concentrate.

Discussion

The important question to which this report addresses is that of the fate of viruses in the natural aqueous environment. The focus has been on the soluble components in ocean water with the capacity to cause virus inactivation.

The inactivation of Po-2 in natural, filter-sterilized ocean surface water was found to be biphasic with a rapid phase ($T_{99.9\%} = 30$ d) accounting for the loss of about 80% of the virus infectivity. The much slower secondary inactivation rate ($T_{99.9\%} = 400$ d) was likely due to the presence of aggregates in the stock of purified Po-2, an hypothesis supported by the observation that about 20% of the infectivity of the highly purified virus migrated more rapidly than for individual Po-2 particles in rate-zonal gradients. This rapid component contained the same polypeptide pattern indicative of intact Po-2, and all but 1% of the label was in the four viral polypeptides. Both pH and salinity were found to affect the rate of Po-2 inactivation. Increasing the salinity and hydrogen ion concentrations increased the initial rates of inactivation and reduced the biphasic nature of the curves. This latter process is likely due to disaggregation of virus aggregates at higher pH and salinity rendering a monomeric virus more sensitive to inactivating events surrounding it.

The resolution of virus polypeptides or BSA by SDS polyacrylamide gel electrophoresis following long incubations in filter sterilized ocean water suggested proteolytic activity (Figures 2 and 4). The activity was destroyed by autoclaving and was neither dialyzable nor present in autoclaved-filtered deionized or ocean water. In control long term incubation studies proteolytic activity was not detected in the preparations of either ^{125}I -BSA or ^{14}C -Po-2. Mixing experiments demonstrated that an inhibitor of virus inactivation did not form during autoclaving. Thin channel ultrafiltration resulted in concentration of the activity thus providing a process more amenable to laboratory experimentation. The point must, however, be made that the concentrated activity may be a mixture of activities which will require considerable dissection and study. Furthermore, the concentrated activity may be unrelated to that studied in the unconcentrated samples.

The phenomenon of natural virucidal activity in water was first reported by Plissier and Therre (1961). These authors reported that the inactivation of poliovirus type 1 (Mahoney) in seawater depended upon the initial virus concentration seeded and was such that at 17°C, seedings of $10^{4.8}$ TCID₅₀ resulted in active virus after 150 d. In studies of the infectivity of poliovirus type 1 in seawater obtained from the Gulf of Mexico, Akin et al. (1976) reported loss of viral activity in raw, filter-sterilized, and autoclaved water. Virus infectivity was also lost in water composed of dilutions of artificial seawater and deionized water, but not as rapidly in deionized water alone. Virus inactivation was more rapid in estuarine water than in natural freshwater. Control experiments demonstrated the absence of con-

tainer interactions and viral aggregation. Studies supporting the virucidal activity of seawater have been reported by Lycke et al. (1965) and Magnusson et al. (1966) who demonstrated that waters from the Baltic and North Seas, respectively, possessed virucidal activity for six common enteric viruses. The rate of inactivation ($T_{90\%} = 6-9$ d) was decreased by boiling. In contrast, freshwater samples were devoid of virus inactivating activity above that predicted by thermal decay. Water samples from the Mediterranean Sea (Matossian and Garabedian, 1967; Shuval et al., 1971) and the North Atlantic Ocean (McLean and Brown, 1968) have also been shown to possess virus-inactivating capacity. In these studies a decrease of 90% (90%) required about 2 days and filter sterilization removed this rapid inactivation capacity. In each of the preceding reports and as presented in the review by Katzenelson (1978) there is consensus that marine antiviral activity exists in seawater provided that a 3-log inactivation of poliovirus occurs within a 7 day period at 15°C. Our studies ($T_{90.0\%} = 20$ d, at 17°C) suggest that such an active marine antiviral activity was either not present in our collected samples or was removed by filter sterilization.

There has been no report of a successful isolation of any specific and active marine virus inactivating factor. A nondialyzable factor which was apparently responsible for inactivation of poliovirus by Rio Grande river water was reported by O'Brian and Newman (1977). The active principal was found to be sensitive to heat and was considered proteinaceous in nature but was not isolated.

Microbial degradation of particulate organic matter i.e. protein, carbohydrate, hemicellulose, is an essential component of carbon recycling in natural waters. In waters of moderate depths as much as 75 to 99% of particulate organic matter produced autotrophically in the epilimnion was degraded before reaching the sediment (Ohle, 1962). In another study some 88% was decomposed before leaving the epilimnion (Wetzel et al., 1972).

Proteolysis is important in the solubilization of protein in natural waters as it may affect the rate of sedimentation and, thus, the degree of anaerobiosis in the hypolimnion and at the sediment surface. Microbial proteases are frequently produced by members of the genera *Pseudomonas*, *Vibrio*, and *Acinetobacter*, and both production and excretion are known to be under the control of complex regulatory phenomenon. As yet, there has been no conclusive proof of the action of proteolytic enzymes from these microorganisms on either naturally occurring soluble or particulate protein or viruses in environmental situations.

Using an assay which measured the rate of release of soluble azure dye derivative from hyde powder, Little et al. (1979) determined that natural unfiltered waters from lake Chaplain were proteolytic, the activity most closely associated with waters containing *Pseudomonas* and *Flavobacterium* species. They did not detect activity in water sterilized by microfiltration. Rinderknecht et al. (1968) quantified the dye-solubilization

assay for several proteolytic enzymes. The assay was useful for the detection of proteolytic activity in the range of 0.01 μg /ml of trypsin and was proportional to enzyme concentration at levels of 0.1 μg /ml and above. Since many proteinases require specific substrates and cofactors and since the soluble proteolytic activity in natural waters can be expected to be very low, it is likely that some proteolytic activities would remain undetected using of dye-solubilization assay.

Laboratory studies have suggested that enterovirus titer reduction is a consequence of microbial growth or degradation. Magnusson et al. (1967) reported a relationship between virus inactivation capacity of seawater and mixed cultures of marine bacteria. Gunder-son et al. (1967) isolated a pure *Vibrio* culture which possessed virus inactivation capacity. Ramanathan et al. (1968) demonstrated antiviral activity in extracts of *Propionibacterium freudenreichii*. The name "propionin" was applied to bacterial extracts which were reported to be effective against vaccinia and lymphocytic choriomeningitis virus. Kelley et al. (1961) identified and prepared pure cultures of *Flavobacterium*, *Klebsiella*, and coliform strains from wastewater sludge that were capable of rapid poliovirus inactivation. Sobsey and Copper (1971) reported that a mixed culture of *Scenedesmus quadricauda* and an unspecified bacteria reduced poliovirus infectivity by three logs at 25°C in three days.

Cliver and Herrmann (1972) demonstrated that some enteroviruses are susceptible to specific hydrolytic or proteolytic enzymes. Coxsackievirus type A-9 and also the poliovirus strains, 1, 2, and 3 were found susceptible to lysozyme and neutral protease from *Galus gallus* and *Bacillus subtilis*, respectively. Both *Bacillus subtilis* and *Pseudomonas aeruginosa* showed marked ability to inactivate Coxsackievirus type A-9 when added to the virus in sterile deionized water samples. Experiments with amino acid labeled virus preparations indicated that at least some portion of the virus particle was degraded and the release protein could be used as a substrate for bacterial growth. Cliver attributed most of the inactivation to processes involving enzymic proteolytic action, but further reported that a material with apparent molecular weight of 500 or less was involved.

The cumulative data suggests, at least in laboratory experiments, that biological mechanisms promulgated by microorganisms or other organisms may play an essential role in natural processes of virus inactivation in water. In this report we have measured the rates of inactivation of Po-2 in waters obtained from the Tide-water area of Virginia and have detected and concentrated a heat sensitive, nondialyzable proteolytic activity from marine surface water that appears to be responsible for the hydrolysis of Po-2 capsid proteins.

Literature Cited

- Akin, E. W., Benton, W. H., and Hill, W. F. (1971). Enteric Viruses in Ground and Surface Waters: a review of their occurrence and survival. In *Proceedings — 13th Water Quality Conference*. Engineering Publications, University of Illinois, Urbana, pp. 59-74.

- Akin, E. W., Hill, W. F., Jr., Cline, G. B., and Benton, W. H. (1976). The Loss of Poliovirus 1 Infectivity in Marine Waters. *Water Research* 10, 59-63.
- Baum, S. G., Horowitz, M. S., and Maizel, J. V., Jr. (1972). Studies on the Mechanism of Enhancement of Human Adenovirus Infection in Monkey Cells by Simian Virus-40. *J. Virology*, 10, 211-219.
- Berg, G. (1973). Reassessment of the Virus Problem in Sewage and in Surface and Renovated Water. *Progress in Water Technology*, 3, 87-94.
- Cliver, D. O. and Herrman, J. E. (1972). Proteolytic and Microbial Inactivation of enteroviruses. *Water Research*, 6, 797-805.
- Gerard, G. F., Johnson, J. C., and Boezi, J. A. (1972). Release of the Subunit of *Pseudomonas putida* Deoxyribonucleic Acid-Dependent Ribonucleic Acid Polymerase. *Biochemistry*, 11, 989-997.
- Gunderson, K., Brandberg, A., Magnusson, S., and Lycke, E. (1967). Characterization of a Marine Bacterium Associated with Virus Inactivating Capacity. *Acta. Path. et. Microbiol. Scandinav.* 71, 281-286.
- Hunter, W. M. (1967). In *Handbook of Experimental Immunology*, D. M. Weir, ed. F. A., Davis, Philadelphia, p. 608.
- Katzenelson, E. (1978). Survival of Viruses. In *Indicators of Viruses in Water and Food*. (G. Berg, ed.) Ann Arbor Science, Ann Arbor, pp. 39-50.
- Kelley, S., Sanderson, W. M., and Neidl, C. (1961). Removal of Enteroviruses from Sewage by Activated Sludge. *J. Water Pollut. Control Fed.* 33, 1056-1062.
- Little, J. E., Sjogren, F. E., and Carson, G. R. (1979). Measurement of Proteolysis in Natural Waters. *Appl. Environ. Microbiol.* 37, 900-908.
- Lycke, E., Magnusson, S., and Lund, E. (1965). Studies on the nature of the Virus Inactivating Capacity of Sea Water. *Archs. Ges. Virus*, 17, 409-413.
- Maizel, J. V. (1971). Polyacrylamide Gel Electrophoresis of Viral Proteins. In "Methods in Virology" (K. Maramorosch and H. Koprowski, eds.), Vol. V. p. 180. Academic Press, New York.
- Magnusson, S., Gunderson, K., Brandberg, A. and Lycke, E. (1967). Marine Bacteria and Their Possible Relation to the Virus Inactivating Capacity of Sea Water. *Acta. Path. et. Microbiol. Scandinav.* 71, 274-280.
- Magnusson, S., Hedstrom, C. E., and Lycke, E. (1966). The Virus Inactivating Capacity of Sea Water. *Acta. Path. et. Microbiol. Scandinav.* 66, 551-559.
- Matossian, A. M., and Garabedian, G. A. (1967). Virucidal Action of Sea Water. *Am. J. of Epidemiol.* 85, 1-8.
- McEwen, C. R. (1967). Tables for Estimating Sedimentation Through Linear Concentration Gradients of Sucrose Solution. *Anal. Biochemistry*, 20, 114-149.
- McLean, D. M., and Brown, J. R. (1968). Marine and Freshwater Virus Dispersal. *Can. J. Publ. Hlth.* 59, 100-104.
- Melnick, J. L. (1978). Water as a Reservoir of Virus in Nature and Means for Control. In *Viruses and Environment*. (E. Kurstak and K. Maramorosch, ed.). Academic Press, New York, pp. 203-226.
- O'Brian, R. T., and Newman, J. (1977). Inactivation of Polioviruses and Cocksackieviruses in Surface Water. *Appl. Environ. Microbiol.* 33, 334-340.
- Ohle, W., (1962). Der Stoffhaushalt der Seen als Grundlage einer Allgemeinen Stoff-Wechseldynamik der Gewasser. *Kiel. Meeresforsch.* 18: 107-120.
- Plissier, M. and Therre, P. (1961). Recherches sur l'inactivation *in vitro* du Poliovirus dans l'eau de Mer. *Ann. Inst. Pasteur.* 101, 840-844.
- Ramanathan, S., Wolyne, C., and Cutting, W. (1968). Antiviral Principles of *Propionibacterium*—Isolation and Activity of Propionins B and C. *Proc. Society of Experimental Biol. and Medicine*, 129, 73-77.
- Rinderknecht, H., Geokas, M. C., Silverman, P., and Haverback, B. J. (1968). A New Ultrasensitive Method for the Determination of Proteolytic Activity. *Clinica Chimica Acta*, 21, 197-293.
- Shuval, H. I., Thompson, A., Fattal, B., Cymbalista, S., and Wiener, U. (1971). Natural Virus Inactivation Processes in Seawater. *J. Sanit. Engin. Division Proc. Amer. Soc. Civil Engineers*, SA5, 587-600.
- Sobsey, M. D., and Cooper, R. C. (1971). Laboratory Studies on the Survival of Poliovirus in Algal-bacterium Wastewater Treatment Systems. In *Proceedings — 13th Water Quality Conference*. Engineering Publications, University of Illinois, Urbana, pp. 137-147.
- Ward, R. L., and Ashley, C. S. (1976). Inactivation of Poliovirus in Digested Sludge. *Appl. Environ. Microbiol.* 31, 921-930.
- Ward, R. L. and Ashley, C. S. (1977). Inactivation of Enteric Viruses in Wastewater Sludge through Dewatering by Evaporation. *Appl. Environ. Microbiol.* 34, 564-570.
- Wetzel, R. G., Rich, P. H., Miller, M. C., and Allen, H. L. (1972). Metabolism of Dissolved and particulate Detrital Carbon in a Temperate, Hard-Water Lake. *Mem. Ist. Ital. Idrobiol.* 29, (Suppl.), 185-243.

Vascular Flora of the Jones and Mill Creek Watershed, Powhatan County, Virginia*

Celeste M. Corcoran-Diggs¹ and Gustav W. Hall

Department of Biology
College of William and Mary
Williamsburg, Virginia 23185

Abstract—This floristic study in the southeastern Virginia Piedmont began in February, 1976 and continued until June, 1977. The study area encompasses approximately 25 square miles in north-eastern Powhatan County. The boundaries of the area include the James River and the natural watershed divides of Jones and Mill Creek. Some of the more interesting and unusual habitats in the area, to which special attention was paid in this study, include the rocky bluffs and steep ravines along the James River, the granitic outcrops which occur throughout the area, and two extensive swamps, each adjoining an old mill pond. While interesting and sometimes unusual species were found in these habitats, the characteristic Piedmont flora was also observed and collected throughout the study area.

A total of 814 species of vascular plants have been collected and identified, the majority of which are new Powhatan County records. Some of the distributional records established include *Eriochloa gracilis*, a state record, and *Crotalaria mucronata* and *Iresine rhizomatosa*, both new Piedmont records.

The geology of the study area is discussed, and a phytogeographical analysis made of the flora of the Jones and Mill Creek Watershed. The geographical affinities of the flora are similar to those of the state of Virginia as a whole, being most closely related to the flora of temperate eastern and midwestern North America, and with smaller circumboreal, eastern Asiatic, tropical, and cosmopolitan links.

Introduction

The Jones and Mill Creek Watershed is located in the Fine Creek Mills area of northeast Powhatan County, in the southeast section of the Virginia Piedmont. The study area, encompassing approximately 25 square miles, is delimited by major watercourses and by highways that follow natural watershed divides: The James River on the north, Fine Creek and Virginia Route 628 on the west, Virginia Route 671 on the south, and Norwood Creek and Virginia Routes 613 and 614 on the east. The study area includes Jones Creek east of Virginia Route 628, and its tributary Mill Creek. Also included is the continuation of Jones Creek below Woodberry Pond, Norwood Creek, and Fine Creek north of Virginia Route 711. Elevation in the study area ranges from 150 ft. on the James River to 450 ft. in the southern half of the area.

The Piedmont location of the study area was chosen with the deficiencies in the overall floristic knowledge of the state in mind. In the past the Piedmont has been considered by botanists to be floristically depauperate and therefore the least attractive of the physiographic provinces in Virginia (Harvill 1969a), and thus its flora is the least known. There are also many mountain-coastal plain disjuncts in Virginia (Harvill 1965, 1972, 1975), and only as more work is done in the Piedmont will it be known if these disjuncts are real, or merely

collecting artifacts. Besides small collections made by Johnson (1970, 1972a), only scattered collecting has been done, and few published records exist for Powhatan County. The Fine Creek Mills area of Powhatan County has three very interesting habitats: steep rocky bluffs along the James River, two old mill ponds and their associated swamps, and a series of granitic rock outcrops which occur throughout the study area. Thus, the Jones and Mill Creek Watershed seemed an ideal location for a floristic study. In addition to the study of the flora of the Jones and Mill Creek Watershed, the geographical affinities of the flora are analyzed.

Methods

Collection of specimens of the vascular flora of the Jones and Mill Creek Watershed began in February 1976, and continued until June 1977. In order to be as thorough as possible in the collection of the flora, sites representative of each habitat type present in the area were visited and collected at on each expedition. Specimens were collected in triplicate and numbered with the first author's collecting number. Note was made of the location, habitat, and abundance of each plant. Abundance was classified as rare (one to few individuals seen), uncommon (several individuals seen), occasional (small colonies seen at more than one site), common (colonies seen at several sites), or abundant (colonies seen throughout the area). After pressing and identification of the specimens, the voucher set was deposited in the herbarium of the College of William and Mary (WILL). Additional sets of specimens are deposited at the University of North Carolina at Chapel Hill (NCU), Tulane University (NO), and Southern Methodist University (SMU).

The following manuals were used for identification

Footnotes

*Based on a Master's thesis submitted to the College of William and Mary, Williamsburg, Virginia, and funded in part by that institution. The authors wish to extend special thanks to Dr. D. M. E. Ware and Dr. George M. Diggs, Jr., for their constant assistance and encouragement throughout the study, and also to Dr. Stewart Ware and Dr. Gary Breckon for their help in editing the manuscript. For allowing us to collect freely on their property and sharing their knowledge of the area with us, we extend our gratitude to the Jervey family of Powhatan County.

¹Present address: Box 1564, Austin College, Sherman, Texas, 75090.

of the specimens: Radford, Ahles, and Bell (1968), Gleason and Cronquist (1963), Gleason (1952), Fernald (1950), Bailey (1949), Hitchcock (1935), Rehder (1967), and Gould (1975).

Nomenclature follows Radford, Ahles, and Bell (1968), except where noted, and in that case follows Hitchcock (1935).

Determination of state, Piedmont, southern Piedmont (south of the James River), and county distributional records was made by consulting the published records of Allard and Leonard (1943, 1944, 1952, 1962), Boule (1979), Bradley (1972), Crow (1978), Diggs and Hall (1981), Duncan (1967), Harvill (1967, 1969a, 1973a, 1977), Hathaway and Ramsey (1973), Hill (1980), Johnson (1970, 1971a, 1971b, 1972a, 1972b, 1974a, 1974b, 1974c), Johnson and Joosten (1977), Kral and Bostick (1969), Lewis (1958), Massey (1961), Mazzeo (1972), Nessler (1976), Parker (1977), Ramsey (1967), Ramsey, et al. (1969), Roane (1975), Roe (1977), Shinnars (1962), Smith (1976), Thacker, et al. (1968), Uttal and Mitchell (1970), and Woodson, et al. (1977).

The geographical range of the plants of the Jones and Mill Creek Watershed was determined by consulting Fernald (1950), Gleason (1952), Gleason and Cronquist (1963), Small (1933), Hitchcock (1935), Harvill (1973b), Li (1952), and Hultén (1937, 1958). The phytogeographical range patterns used were adapted from Harvill (1973b).

The annotated checklist of the flora of the Jones and Mill Creek Watershed includes each species' abundance, range, habitat, and collecting number(s). Distributional records are indicated in the checklist. In addition, the taxa are enumerated according to their geographical range and habitat, and the significant phytogeographical affinities of the flora are discussed.

Geology

Powhatan County lies within the Piedmont physiographic province, the non-mountainous portion of the "older Appalachians" (Fenneman 1938). The Piedmont plateau surface, which has a gentle southeast slope, is the result of the degradation of its crystalline rocks, both sedimentary and igneous, which have been greatly altered by metamorphism (Watson 1907). The topography of Powhatan County is similar to the rest of the Piedmont, a rolling surface of gentle slopes into which streams have sunk their channels.

The study area lies within the gneisses and schists of the eastern Virginia Piedmont. There are three important formations along the James River in Powhatan County. The State Farm Gneiss is a north-northeast trending doubly plunging antiform which extends south of the James River throughout the study area. The Fine Creek Mills Granite occupies the core of this antiform. The Fine Creek Mills Granite outcrops at Fine Creek Mills and other places in the study area due to severe erosion of the antiform. Above the State Farm Gneiss and flanking the antiform is the Sabot Amphibolite. The James River floodplain in the study

area is covered with a Quaternary alluvium of sand, silt, and gravel. The bluffs along the river are topped by beds of Tertiary gravel. (Poland and Glover 1976).

Also important in the geology of the area is the Richmond Basin, a Mesozoic basin which lies in several counties, including the eastern portion of Powhatan. The rocks bordering on and underlying the basin are the typical Piedmont granites and gneisses. The basin itself is a series of sandstone, shale and coal beds. The Richmond Basin was the first source of coal in the United States and was mined for many years. (Watson 1907).

The Piedmont province is not noted for its soil fertility, and erosion has long been a problem. The alluvial plains offer the best soils. (Fenneman 1938). The soil type in the study area is the common one all over the Piedmont, red and yellow podzolic. It has a thin dark-colored organic layer over a yellow-grey or grey-brown leached layer over a darker clayey layer of deposition which grades into the deeply weathered parent material. (Hunt 1972). There are two soil associations that are important in the study area. In the lowland along the river occurs the *Altavista-Wicham-Chewacla* association, a moderately drained soil with a yellowish-brown to yellowish-red friable clay loam to gray silty loam subsoil. In the upland of the area occurs the *Cecil-Masada* association, a deep well drained soil with a red to yellowish-red firm clayey subsoil. (United States Department of Agriculture Soil Conservation Service 1972).

Vegetational Patterns

The Fine Creek Mills area of Powhatan County has, in addition to the typical Piedmont topography and vegetation, three unusually interesting habitats, to which special attention has been paid in this study: the steep rocky bluffs and ravines on the James River, the series of granitic rock outcrops which occur throughout the area, and the two old mill ponds and their associated swamps. Many of the unusual and floristically interesting species were found in these habitats, but the characteristic Piedmont flora was also observed and collected throughout the entire study area.

The James River valley is quite a diverse portion of the study area, with its rocky bluffs, rich ravines, and flat floodplains, both open and wooded. *Polypodium virginianum*, *Carex blanda*, *C. platyphylla*, *Iris cristata*, *Erythronium americanum*, *Sanguinaria canadensis*, and *Rhododendron nudiflorum* are characteristic species found on the bluffs of the James. An association of *Dicentra canadensis*, *Asarum canadense*, *Adiantum pedatum*, and a large colony of *Jeffersonia diphylla* is growing in one particularly rich and steep ravine. In another ravine through which a stream flows into the James grows *Carex albursina*, *Habenaria clavellata*, *Orchis spectabilis*, *Liparis lilifolia*, *Melanthium virginicum*, *Uvularia pudica*, *Aristolochia serpentaria*, and *Matelea suberosa*. Species commonly growing along the floodplain of the James include *Inupaiensis capensis*, *Ellisia nyctelea*, *Nemo-*

phila microcalyx, *Humulus japonicus*, *Conium maculatum*, *Erysimum cheiranthoides*, and several *Solidago* spp. Other species, such as *Impatiens pallida*, *Hydrophyllum canadense*, *Arisaema dracontium*, *Sicyos angulatus*, *Erigeron philadelphicus*, *Agastache nepetoides*, and *Iresine rhizomatosa* are also found along the floodplain, although much less frequently. Interesting grasses recorded along the floodplain include *Arthraxon hispidus*, *Eragrostis hypnoides*, *Microstegium vimineum*, and *Paspalum fluitans*.

The upland woods in the study area are of several types. In the deciduous woods in sites such as the bluffs the common species include *Quercus alba*, *Q. falcata*, *Q. prinus*, *Carya ovalis*, *C. tomentosa*, *Cercis canadensis*, *Ostrya virginica*, *Carpinus caroliniana*, and *Chionanthus virginicus*. Stands of mixed pine-deciduous woods are common in the study area. The typical tree species seen in these woods are *Pinus virginiana*, *P. echinata*, *Juniperus virginiana*, *Quercus alba*, *Carya tomentosa*, *Cornus florida*, and *Ilex opaca*. There are also several pure pine stands of *Pinus virginiana* and *P. echinata* in the area. Shrubs such as *Gaylussicia baccata*, and *Vaccinium stamineum* are common in the pine woods, as are herbs such as *Cypripedium acaule*, *Chimaphila maculata*, and *C. umbellata*.

Low woods occur on the floodplain of the James as well as surrounding the streams, lakes, and ponds in the area. Here *Acer rubrum*, *A. negundo*, *A. saccharinum*, *Liquidambar styraciflua*, *Nyssa sylvatica*, *Betula nigra*, *Salix nigra*, and *Carpinus caroliniana* are found, as well as *Platanus occidentalis*, *Fraxinus pennsylvanica*, *Liriodendron tulipifera*, *Ulmus americana*, *Carya cordiformis*, and *Cornus florida*. Shrubs found around wet areas include *Alnus serrulata*, *Cephalanthus occidentalis*, *Ilex virginica*, and *Leucothoe racemosa*.

Two of the old mill ponds in the area, Woodberry Pond on Jones Creek and Mill Pond on Mill Creek, have extensive swamps behind them, and many interesting taxa occur in these waterways. *Potamogeton diversifolius*, *P. epiphydrus*, *Spirodela polyrrhiza*, *Egeria densa*, *Heteranthera reniformis*, *Utricularia biflora*, *Callitriche heterophylla*, *Nuphar luteum*, and *Nymphaea odorata* are some of the aquatics found. Common emergents include *Juncus* spp., *Carex* spp., *Cyperus* spp., *Dulichium arundinaceum*, *Alisma subcordatum*, *Sagittaria latifolia*, *Sparganium americanum*, *Peltandra virginica*, and *Chelone glabra*. Herbs found in low woods surrounding the waters include *Lycopodium lucidulum*, *Selaginella apoda*, *Symplocarpus foetidus*, *Dryopteris cristata*, *Ophioglossum vulgatum*, *Chrysosplenium americanum*, *Euphorbia obtusata*, *Aconitum uncinatum*, *Habenaria lacera*, *H. flava*, and *Apios americana*. Common bottomland grasses are *Eragrostis capillaris*, *Glyceria striata*, *Leersia virginica*, *Panicum capillare*, *P. stipitatum*, *Poa sylvestris*, and *P. trivialis*.

Granitic rock outcrops occur throughout the study area, with two very extensive ones at Fine Creek Mills and Flat Rock. These outcrops were surveyed by Berg in his study of the vegetation and succession on Pied-

mont granitic outcrops in Virginia (Berg 1974). While several southeastern outcrop endemics such as *Sedum pusillum*, *Portulaca smallii*, *Cyperus granitophyllus*, and *Juncus georgianus* are not found on the outcrops in Powhatan, other characteristic species are found. Typical dicotyledons growing on the outcrops are *Opuntia compressa*, *Arenaria groenlandica* var. *glabra*, *Talinum teretifolium*, *Crotonopsis elliptica*, *Portulaca oleracea*, *Phacelia dubia*, *Linaria canadensis*, *Krigia virginica*, *Sherardia arvensis*, and *Hypericum gentianoides*. Outcrop pteridophytes and monocotyledons include *Selaginella rupestris*, *Cyperus aristatus*, *Eleocharis engelmannii*, *E. obtusa*, *Fimbristylis autumnalis*, *Bulbostylis capillaris*, *Xyris torta*, *Agrostis elliptica*, and *Panicum laxiflorum*.

Successional areas around Fine Creek Mills include mostly abandoned fields, and these are quite common as farms are sold to build subdivisions. Interesting species found in abandoned fields are *Kickxia elatine*, *Abutilon theophrasti*, *Thlaspi arvense*, *Isoetes brachiatus*, and *Triosteum perfoliatum*. More commonly found are *Asclepias* spp., *Solidago* spp., *Erigeron* spp., *Eupatorium* spp., *Liatris squarrosa*, *Spiranthes gracilis*, *S. gravi*, *Papaver dubium*, and *Centaurea cyanus*. Grasses found in old fields include *Eragrostis spectabilis*, *Sorghum halepense*, *Setaria* spp., and *Andropogon* spp.

At the most recently disturbed areas such as roadsides and building sites are found many weedy species. The most common grasses are *Panicum* spp., *Paspalum* spp., *Aristida* spp., *Andropogon* spp., *Aira caryophyllaea*, *A. elegans*, *Eragrostis curvula*, *Erianthus contortus*, *Miscanthus sinensis*, and a grass newly reported for Virginia, *Eriochloa gracilis*. Other herbs found in disturbed areas include *Holosteum umbellatum*, *Aster* spp., *Coreopsis lanceolata*, *C. verticillata*, *Daucus carota*, *Amaranthus* spp., *Baptisia tinctoria*, *Lespedeza* spp., *Desmodium* spp., *Trifolium* spp., and *Viola* spp.

Phytogeography

The physiographic diversity of Virginia and its escape from past glaciation, combined with a relatively long and favorable growing season, has resulted in a rich flora of diverse affinities. Relationships with the floras of subtropical, tropical and boreal North America occur, as well as affinities to western North America, eastern Asia, and western Europe (Harvill et al. 1977).

The ranges of the species of the Jones and Mill Creek Watershed fall into seven categories (modified from Harvill 1973b):

1. Circumboreal, totally circumboreal or interrupted.
2. Native to North America and Eastern Asia.
3. Native to North American and extending to both the Atlantic and Pacific coasts.
4. Native to temperate North America and the West Indies, Mexico, or Central or South America.
5. Native to eastern North America. The majority of these species range west beyond the Mississippi

River, but do not extend to the Pacific coast.

6. Widespread species which extend south of the United States and to the Old World.

7. Introduced species, now naturalized.

The distributions given are for the species, and include any subspecific taxa. Distributions were determined by consulting Fernald (1950), Gleason (1952), Gleason and Cronquist (1963), Small (1933), Hitchcock (1935), Harvill (1973b), Li (1952), and Hulten (1937, 1958). Because no single author is comprehensive in range descriptions, especially in the case of ranges extending outside the United States, no one source is taken as absolute. The range listed for each species is the composite of all distributions as listed by each author, and is thus subject to some error, as workers' concepts of a particular species may vary.

The species are further divided into groups according to the habitat where they occurred most commonly. Since the study was basically floristic, no attempt was made to exhaustively sample each species' ecological amplitude. Dividing the habitats into more precise units did not result in any meaningful patterns, so rather broad, and often heterogeneous categories were used. The habitat categories are:

1. Forest; includes the dryer upland and more mesic to wet lowland woods.
2. Disturbed sites; includes a variety of sites that experience continued or interrupted physical disturbances, such as moving, grazing, periodic inundation, etc.
3. Aquatic; includes those species growing in water.
4. Rock outcrop; includes species growing on the exposed granitic outcrops which occur throughout the area.
5. Not classified; includes species that occur commonly in several habitats and are not characteristic to any one.

The general phytogeographical affinities of the flora of the Jones and Mill Creek Watershed are shown in Table 1. In general, the affinities are not unlike those of the state of Virginia as a whole, although the relative proportions may differ (Harvill et al. 1977). The region and its flora are clearly continuous with the flora of eastern North America. The flora of the Jones and Mill Creek Watershed encompasses no endemics, and only 25% of the native species extend beyond the temperate eastern-midwestern regions of North America. The southern element comprises approximately 11% of the total flora; and while these species occur in all the habitats, and are most numerous in the disturbed sites, they are most important in the aquatic and rock outcrop floras.

The circumboreal species are a minor element in the flora, which given the Piedmont location of the study area, is not surprising. These species are most common in the forests, and seven of the 20 species involved are pteridophytes, including *Botrychium virginianum*, *Dryopteris cristata*, *Ophioglossum vulgatum*, and *Polypodium virginianum*. Both the pan-North American and widespread elements are relatively small, and neither show any distinct correlation with any particu-

TABLE 1

Phytogeographical relations of the Jones and Mill Creek Watershed flora. See text for discussion of ranges and habitats. For each habitat the number of species in each range category is given in the first row, the percentage of the total flora of each range-habitat category is in the second row, and the percentage of the species within the habitat for each distribution range is given in the third row. The total number of species in each habitat and their percentage of the flora are given in the far right column. The total number of species for each range category and their percentage of the flora are given in the bottom two rows.

HABITAT	RANGE 1 Circumboreal	RANGE 2 N. America & E. Asia	RANGE 3 Pan-N. America	RANGE 4 S. of U.S.	RANGE 5 E. N. America	RANGE 6 Widespread	RANGE 7 Introduced	Total
Forest	12	7	10	19	282	3	13	346
%flora	1.5	0.9	1.2	2.3	34.7	0.4	1.6	42.6
%habitat	3.5	2.0	2.9	5.5	81.5	0.9	3.7	-
Disturbed	6	1	16	45	165	4	152	389
%flora	0.7	0.1	2.0	5.5	20.3	0.5	15.7	47.9
%habitat	1.5	0.3	4.1	11.6	42.4	1.0	39.1	-
Aquatic	1	-	6	13	12	3	1	36
%flora	0.1	-	0.7	1.6	1.5	0.4	0.1	4.4
%habitat	2.8	-	16.7	36.1	33.3	8.3	2.8	-
Rock outcrop	-	-	9	17	-	5	31	51
%flora	-	-	1.1	2.1	-	0.6	3.8	-
%habitat	-	-	29.0	54.8	-	16.1	-	-
Not classified	-	-	2	5	-	3	10	10
%flora	-	-	0.2	0.6	-	0.4	1.2	-
%habitat	-	-	2.0	30	-	30	-	-
Total	19	8	32	88	481	10	174	812
%flora	2.3	1.0	3.9	10.8	59.2	1.2	21.4	100

lar habitat. The other minor floristic group is the eight species, seven of which occur in the forests, that demonstrate the connection—or at least an ecological similarity—between temperate east Asia and North America. Had analysis been done on the generic level the relationship between the two floras would be more evident (Li 1952). However, *Onoclea sensibilis*, *Lycopodium obscurum*, *Symplocarpus foetidus*, *Monotropa uniflora*, *Phryma leptostachya*, *Tovara virginiana*, *Adiantum pedatum*, and *Carex pensylvanica* do show the east Asian affinity of the flora. It is not possible to ascertain whether these distributions are due to the fragmentation of a once continuous paleoflora, or to long distance dispersal and the presence of similar habitats.

The extent of human impact on the area is evident, with nearly half of the flora occurring in disturbed sites and approximately 20% of the total flora being introduced. The majority (87%) of the introduced species occur in disturbed sites. Some possible exceptions are *Rumex acetosella*, *Sedum sarmentosum*, and *Scleranthus*.

thus annuus which have become established on rock outcrops. However, the outcrop habitat includes micro-environments of low biotic and high abiotic stress (Shure and Ragsdale 1977), which may explain success of the exotics. The establishment of such species as *Ailanthus altissima*, *Vicia hirsuta*, *Perilla frutescens*, and *Polygonum hydropiper* in the forest may be more a reflection of disturbance in the habitat, than of their ability to invade closed vegetation.

Distribution Records and Annotated Checklist of the Vascular Flora of the Jones and Mill Creek Watershed

A total of 812 species representing 433 genera of 120 families of vascular plants are recorded here for Powhatan County. Six hundred fifty-three of these species have not been reported in the literature as occurring in Powhatan County. Twenty-four of the 653 are new to the Piedmont of Virginia, and 51 of the 653 have not been reported to occur in the Virginia Piedmont south of the James River. One species, *Eriochloa gracilis*, is newly reported for the state of Virginia. Other species of special distributional interest are *Crotalaria mucronata*, previously reported in Virginia only from Gloucester County in the Coastal Plain, and *Iresine rhizomatosa*, previously reported in Virginia from four Coastal Plain counties.

None of the species newly recorded for the Piedmont or southern Piedmont in Virginia in this study are classical mountain-coastal plain disjunct species

(Harvill 1969b, 1972, 1973c, 1979). All new records are either introduced species or species heretofore known only from the mountains, Coastal Plain, and/or the northern Piedmont.

In the checklist nomenclature follows Radford, Ahles, and Bell (1968) unless noted by a cross (+), and in these cases nomenclature follows Hitchcock (1950). Taxa that are county records are preceded by an asterisk (*); taxa that are southern Piedmont records are preceded by a double asterisk (**); taxa that are Piedmont records by a triple asterisk (***); and state records by four asterisks (****). The name of each taxon is then followed by four codes. First, the abundance of each taxon is indicated by the following abbreviations: R = rare; U = uncommon; O = occasional; C = common; A = abundant. The abundance code is then followed by a number indicating the range of each taxon (range patterns are defined in the Phyto-geographical analysis). The habitat(s) from which each taxon was collected is then indicated by the following abbreviations: LW = lowland woods; UW = upland woods; RO = rock outcrops; AQ = aquatic; B = bluffs on the James River; FP = James River floodplain; S = successional areas; RD = recently disturbed areas. The last number(s) in each entry is the first author's collecting number(s).

The taxa here recorded include: 570 species of dicotyledons representing 316 genera and 91 families; 210 species of monocotyledons representing 97 genera and 18 families; four species of conifers representing two genera and two families; and 28 species of pteridophytes representing 18 genera and nine families.

Annotated Checklist

PTERIDOPHYTA

- ASPIDACEAE: **Arthyrium asplenoides*, C, 5, LW; 1003, 1501. *A.
thelypteroides, U, 5, B; 1417. **Cystopteris protensa*, R, 5, B; 571.
 **Europteris cristata*, C, 1, LW; 679. **D. marginalis*, O, 5, B; 1409. **D.*
spimolosa, O, 1, LW; 1465. *Osmola sensibilis*, O, 2, RD; 1494. *Polystichum*
acrostichoides, C, 4, LW; 12, 908. **Thelypteris hexagonoptera*, O, 5, LW;
 1133. *T. noveboracensis*, O, 5, RD; 1502. *T. palustris*, O, 6, LW; 1468.
Woodsia obtusa, O, 5, RD; 431, 699.
 ASPLENIACEAE: *Asplenium platyneuron*, C, 5, LW; 1003.
 BLECHNACEAE: **Woodwardia areolata*, C, 5, LW; 911.
 LYCOPODIACEAE: *Lycopodium flabelliforme*, A, 5, LW; 1488, 1599. **L.*
lucidulum, O, 5, LW; 305, 1075. **L. obscurum*, A, 2, LW; 86, 836.
 OPHIOGLOSSACEAE: *Botrychium dissectum*, O, 5, UW; 9. *B. virginianum*,
 C, 1, B; 119. **OphioGLOSSUM vulgatum* var. *pycnostichum*, U, 1, LW; 220, 576.
 OSMUNDACEAE: **Osmunda cinnamomea*, O, 6, LW; 200. *O. regalis* var.
speciosa, U, 1, LW; 642.
 POLYPODIACEAE: **Polypodium virginianum*, R, 1, B; 16.
 PTERIDIACEAE: **Adiantum pedatum*, O, 2, B; 1410. *Dennstaedtia punctilobula*,
 O, 5, RD; 1637. *Pteridium aquilinum*, O, 6, LW; 958.
 SELAGINELLACEAE: **Selaginella apoda*, O, 4, LW; 131. *S. rupestris*,
 A, 5, RD; 1517.
 CONIFEROPHYTA
 CUPRESSACEAE: *Juniperus virginiana*, C, 5, RD; 428, 1514.
 PINACEAE: ***Pinus echinata*, O, 5, LW; 1565, 1567. **P. taeda*, O,
 5, RD; 1427. *P. virginiana*, A, 5, UW; 1423.

ANTHOPHYTA

MONOCOTYLEDONEAE

- ALISMACEAE: *Alisma subcordatum*, O, 4, AQ; 1060, 1089. **Sagittaria*
latifolia var. *pumilans*, A, 4, AQ; 815.
 AMARILLIDACEAE: **Hyppoxis hirsuta*, U, 5, RD; 328.
 ARACEAE: **Arisaema dracontium*, O, 5, FP; 795. *A. triphyllum*, C, 5, LW;
 327. *Peltandra virginica*, C, 5, AQ; 604. *Symplocarpus foetidus*, A, 2, B; 83.
 COMBELLACEAE: *Commelina communis*, O, 7, RD; 869, 1400. *C. erecta*, O,
 4, RD; 1097, 1527. *C. virginica*, O, 5, LW; 1054, 1474. **Tradescantia*
virginiana, U, 5, RD; 479.
 CYPERACEAE: **Bulbostylis capillaris*, C, 4, RD; 1120, 1160, 1438.
Carex albulotensens, O, 4, AQ; 662, 1096. **C. alburina*, U, 5, LW; 292.
 **C. blanda*, O, 3, B, RD; 320, 443. **C. caroliniana*, O, 5, RD; 495. **C.*
cephalophora, O, 5, LW; 490, 671. **C. comosa*, O, 3, LW; 1145, 1153. *C.*
complanata, O, 5, LW; RD; 226, 380. **C. grinita*, O, 5, LW; 678. **C. debilis*,
 O, 5, LW; 356. **C. frankii*, O, 5, RD; 698, 1115. *C. gracillima*, O, 5, RD;
 446. *C. grari*, O, 5, FP; 552. **C. grisea*, C, 5, LW; 381, 532. ***C. howei*,
 U, 5, LW; 318. **C. intumescens*, O, 5, LW; 355. *C. laevigata*, O, 5, LW;
 258. **C. leavenworthii*, O, 5, LW; 367. **C. lupulina*, O, 5, LW; 1157. **C.*
lurida, C, 4, LW; 666. **C. muhlenbergii*, O, 5, LW; 489. **C. pensylvanica*,
 O, 2, LW; 115, 331. **C. physocarpa*, U, 4, LW; 215. **C. platyphylla*, C, 5,
 B; 295. **C. prasinia*, O, 5, LW; 221, 391. **C. rosea*, C, 5, LW; 675. **C.*
sparganoides, O, 5, B; 321. **C. squarrosa*, U, 5, LW; 1399. ***C. swanii*,
 O, 5, RD; 412. **C. tricholoides*, O, 5, FP; 569. **C. vulpimoides*, O, 3, LW;
 988. ***Cyperus aristatus*, U, 6, S, 1100. **C. erythrorhizon*, U, 3, LW; 1481.

- **C. ferruginescens*, O, 3, PP: 1302. **C. filiculmis*, O, 5, RD: 1140, 1250.
- C. lancestrimensis*, O, 5, RD: 923a. *C. ovalaris*, O, 5, RD: 919, 1116.
- **C. polystachyos* var. *texensis*, U, 6, RD: 1244. **C. strigosus*, O, 3, LW: RD: 1260, 1363. **Dulichion arundinaceum*, O, 3, AQ: 997, 1148. *Eleocharis engelmannii*, C, 3, AQ: 434. *E. obtusa*, O, 3, AQ: 1091. **E. tenuis*, O, 5, AQ: 622. **Fimbristylis autumnalis*, O, 4, RD: 1095, 1352. **Rhynchospora capitellata*, O, 3, AQ: 1088, 1252. **Scirpus cyperinus*, C, 5, AQ: 980. **S. polyphyllus*, C, 5, AQ: 834, 1207. **S. purshianus*, O, 5, AQ: 1414. **S. validus*, U, 3, AQ: 732. **Scleria oligantha*, U, 4, LW: 788.
- DIOSCOREACEAE: *Dioscorea villosa*, O, 5, LW: 500.
- HYDROCHARITACEAE: *Egeria densa*, A, 7, AQ: 139, 723.
- IRIDACEAE: **Iris cristata*, O, 5, B: 222. **I. pseudacorus*, O, 7, LW: 163. *Sisyrinchium angustifolium*, O, 5, RD: 439.
- JUNCACEAE: *Juncus acuminatus*, O, 4, AQ: 616. **J. bafonus*, O, 4, AQ: 631. *J. coriaceus*, O, 5, AQ: 1128. *J. effusus*, C, 6, LW: RD: 934, 989. *J. marginatus*, O, 5, AQ: 1249a. **J. tenuis*, O, 3, PP: RD: 894, 1019. **Luzula bulbosa*, O, 5, RD: 144. **L. echinata*, O, 5, LW: 230. **L. multiflora*, U, 1, B: 17.
- LINDACEAE: **Lemna perpusilla*, U, 4, AQ: 1536. **Spirodelia polyrrhiza*, O, 4, AQ: 639.
- LILIACEAE: **Allium cepa*, U, 7, RD: 388. **A. vineale*, C, 7, S: 711. **Asparagus officinalis*, U, 7, RD: 405. *Erythronium americanum*, A, 5, B: 49. **Memecylon fulva*, C, 7, RD: 719. **Lilium canadense*, O, 5, LW: 593a. **L. superbum*, U, 5, LW: 1005. **Medeola virginiana*, O, 5, LW: 342. **Melanthium virginicum*, O, 5, LW: 742. **Muscari racemosum*, O, 7, S: 237. **Polygonatum biflorum*, O, 4, LW: RD: 188, 338. **Smilacina racemosa*, C, 5, LW: 198, 284. **Smilax bona-nox*, O, 4, RD: 343. ****S. eckrhata*, O, 5, LW: 314, 1170. **S. glauca*, C, 5, LW: 337. **S. herbacea*, O, 5, LW: 307. **S. hispida*, O, 5, LW: 751. *S. rotundifolia*, O, 5, LW: 358, 667. **Thunbergia perfoliata*, A, 5, LW: 301, 486. **U. podica*, U, 5, LW: 206. **Yucca filamentosa* var. *smalliana*, O, 5, RD: 684.
- ORCHIDACEAE: **Agrostis hymenale*, O, 5, LW: 304. **Corallorhiza odoratissima*, U, 4, LW: 1459. *Cypripedium acaule*, O, 5, LW: 251. *Goodyera pubescens*, O, 5, LW: 839. *Habenaria clavellata*, C, 5, LW: 905. **H. flava*, U, 5, LW: 651. **H. lacera*, O, 5, LW: 1476. **Liparis lillifolia*, R, 5, LW: 341. **Malaxis unifolia*, R, 5, LW: 657. **Orchis spectabilis*, R, 5, B: 334. **Spiranthes gracilis*, U, 5, S: 1012. **S. grayi*, U, 5, S: 1313. **S. ovalis*, O, 5, LW: 1493. **Tupilaria discolor*, U, 5, LW: 985.
- PONACEAE: *Agrostis Elliotiana*, O, 4, RD: 430, 436. **A. hymenalis*, O, 4, RD: 625. **A. perennans*, C, 4, 8, RD: 972b, 1314. **A. stolonifera*, O, 7, RD: LW: 786, 920. **A. carophylla*, U, 7, RD: 502. **A. elegans*, O, 7, RD: 524. **Andropogon scoparius*, O, 5, RD: 1574. **A. tenuarvus*, C, 5, RD: RD: 1451, 1521. *Anthonanthus odoratus*, C, 7, RD: 143. **Aristida curtisii*, O, 5, RD: 1354, 1616. **A. dichotoma*, O, 5, RD: RD: 1573a, 1615. **A. oligantha*, O, 3, RD: 1330. **Archanthus hispidus*, O, 7, PP: 1546. *Avena sativa*, O, 7, S: 640. **Bromus cathericus*, O, 7, PP: 543. *B. japonicus*, O, 7, RD: 713, 817. *B. purgans*, O, 5, LW: 766. *Cinna arundinacea*, C, 5, LW: 996, 1369. **Cynodon dactylon*, C, 7, RD: 759, 886. *Dactylis glomerata*, A, 5, S: 712. **Danthonia sericea*, O, 5, RD: 690. *D. spicata*, O, 3, LW: 661. **Digitaria ischaemum*, O, 7, RD: 1339. **D. sanguinalis*, O, 7, RD: 1023, 1377. **Echinochloa crusgalli*, O, 7, RD: 1193. **Elymus indica*, O, 7, PP: LW: 1299, 1407. **Elymus villosus*, O, 5, PP: 883. *E. virginicus*, C, 5, RD: 942. *Eragrostis capillaris*, O, 5, LW: 1248, 1290. ***E. curvulus*, O, 7, RD: 691, 1584. **E. hirsuta*, O, 5, RD: 1522. **E. hypnoides*, O, 4, PP: 1305. **E. pilosa*, O, 7, RD: PP: 1351, 1581. *E. spectabilis*, O, 4, RD: 1235. **Erianthus alopecuroides*, O, 5, S: 1316, 1412. **E. contortus*, C, 5, RD: 1182. ****Eriochloa gracilis*, U, 4, RD: 1185. *Festuca elatior*, C, 7, PP: 546. **F. myuros*, C, 7, RD: PP: 558, 606. *F. obtusa*, O, 5, LW: 599. *F. octoflora*, U, 3, RD: 464. *Glyceria striata*, O, 4, RD: LW: 447, 682. *Hordeum pusillum*, C, 4, RD: 396. *Hystrix*
- patula*, O, 5, RD: 714. **Laeria virginica*, O, 5, PP: LW: 983, 1304.
- **Loium multiflorum*, O, 7, PP: 545. *L. perenne*, C, 7, RD: 816. *Malva nutica*, O, 5, LW: 386. **Microstegium vinumum*, C, 7, LW: 1548, 1582.
- **Miscanthus sinensis*, A, 7, RD: 1402. **Muhlenbergia schreberi*, O, 4, LW: 1490, 1627. *Panicum anceps*, O, 5, RD: 1324. **P. bosci*, C, 5, LW: RD: 272, 830. **P. capillare*, O, 3, LW: 1241. *P. clandestinum*, O, 5, PP: 541. *P. commutatum*, C, 5, LW: RD: 324, 465. **P. dichotomiflorum*, O, 4, PP: RD: 1200, 1301. *P. dichotomum*, O, 5, LW: 493. *P. laxiflorum*, O, 4, RD: 445, 449. **P. polyanthes*, O, 5, LW: 1055. **P. scoparium*, C, 4, RD: 856, 935. **P. sphaerocarpon*, C, 4, RD: 887. *P. stipitatum*, O, 5, LW: 1218, 1368. **Paspalum dilatatum*, O, 7, RD: 1263. **P. floridanum*, C, 5, RD: RD: 948, 1534. **P. fluitans*, A, 4, PP: 1300, 1540. **P. laeve*, C, 5, RD: 1139a, 1220. *P. pubescens*, U, 5, RD: 1139b. **Poa annua*, C, 7, RD: 114. *P. autumnalis*, O, 5, RD: 429, 433. *P. compressa*, O, 7, RD: 831. *P. cuspidata*, C, 5, B: LW: 129, 44. **P. pratensis*, A, 7, RD: RD: 265, 619. **P. sylvestris*, U, 5, LW: 232a. **P. trivialis*, O, 7, LW: RD: 592, 760. *Secale cereale*, U, 7, RD: 1395. *Setaria faberii*, C, 7, RD: 978. **S. geniculata*, O, 4, RD: 860. **S. glauca*, C, 7, RD: 1194. **S. viridis*, O, 7, RD: 815b. **Sorghastrum nutans*, U, 7, RD: 1394a, 1503. **Sorghum halepense*, C, 7, RD: 806. **Sphenopholis intermedia*, C, 3, LW: PP: 544, 603. **S. nitida*, O, 5, LW: 264, 491. **S. obtusata*, O, 4, LW: 597a. **Sporobolus vaginiflorus*, O, 5, RD: 1605.
- Stipa avenacea*, U, 5, RD: 617. *Tridens flavus*, O, 5, RD: 1142, 1244. **Tripsacum dactyloides*, U, 4, RD: 1268. **Trisetum pennsylvanicum*, O, 5, RD: 638. *Urtica latifolia*, O, 5, RD: RD: 761, 1101. **Zea mays*, O, 7, RD: 924.
- POTENTILLACEAE: **Heteranthera reniformis*, O, 4, AQ: 1482.
- POTAMOGETONACEAE: *Potamogeton diversifolius*, O, 4, AQ: 633. ***P. spidius*, A, 3, AQ: 650.
- SPARGANIACEAE: **Sparganium americanum*, A, 5, AQ: 725.
- TYPHACEAE: *Typha latifolia*, O, 5, LW: 1, AQ: 882.
- XYRIDACEAE: **Xyris tortu*, U, 5, AQ: 1620.
- DICOTYLEDONAE
- AGNATHACEAE: **Justicia americana*, O, 5, PP: 971. **Ruellia carolinensis*, O, 5, RD: 870. **S. purshiana*, U, 5, LW: 504.
- ACERACEAE: **Acer negundo*, O, 5, LW: 60, 542. **A. rubrum*, C, 5, LW: 130.
- ***A. saccharinum*, O, 5, PP: 57, 560.
- ALIZOACEAE: **Mollugo verticillata*, O, 7, RD: 1020.
- ANARANTHACEAE: **Anaranthus hybridus*, C, 7, RD: 1184. **A. spinosus*, C, 4, PP: 1545. ****Tresine rhizomatosa*, Z, 5, PP: 1174.
- ANACARDIACEAE: **Rhus copallina*, O, 5, RD: 937. **R. glabra*, O, 4, RD: 863. **R. radicans*, A, 4, RD: 315. **R. vernicifera*, O, 5, LW: 710.
- ANONACEAE: **Asimina triloba*, A, 5, LW: 113.
- APIACEAE: **Angelica venenosa*, U, 5, LW: 785, 851. ***Chaerophyllum procumbens*, O, 5, LW: PP: 234, 304. **C. californicum*, A, 5, LW: 243. **Cicuta maculata*, O, 4, RD: 936, 1242. **Comum maculatum*, O, 7, PP: RD: 610, 764. **Cryptotaenia canadensis*, U, 5, LW: 387, 783. **Daucus carota*, C, 7, RD: 752. **Hydrocotyle ranunculoides*, C, 4, AQ: 132. **Osmorhiza claytonii*, A, 5, LW: 217. **Oxygallis rigidior*, R, 5, LW: 225. **Sanicula canadensis*, O, 5, LW: 594.
789. ****anigridica*, O, 5, LW: 498. **S. smallii*, O, 5, LW: 767.
- **Thasium barbinode*, O, 5, LW: 499.
- APOCYNACEAE: **Apocynum cannabinum*, O, 3, RD: 976. **Vincetoxicum minor*, C, 7, RD: 20.
- AQUIFOLIACEAE: *Ilex decidua*, U, 5, RD: 1104. **I. opaca*, C, 5, LW: 1596.
- **Ilex verticillata*, O, 5, LW: 659, 1478.
- ARALIACEAE: *Aralia spinosa*, O, 5, LW: 1388.
- ARISTOLOCHIACEAE: **Aristolochia serpentaria*, U, 5, LW: 239, 574. **Anarum canadense*, A, 5, LW: 205. **Helleborus virginicus*, U, 5, LW: 382.
- ASCLEPIADACEAE: **Asclepias speciosa*, O, 5, RD: 309, 390. **A. incarnata*, C, 5, LW: 1000, 1205. **A. syriaca*, C, 5, RD: 688, 756. **A. tuberosa*, O, 4, S: 706.

**A. variegata*, O, 5, RD; 507. **A. viridiflora*, O, 4, RD; 809, 1137. **Matela carolinensis*, U, 5, RD; 1638. **M. subsera*, U, 5, LW; 744.

ASTERACEAE: **Michelia millefolium*, C, 7, RD; 390. **Ambrasia artemisiifolia*, A, 4, RD; 1191. **A. trifida*, O, 4, RD; LW; 1230, 1308. **Antennaria plantaginifolia*, O, 5, LW; 99. **A. solitaria*, O, 5, B; 204. **Artemisia arvensis*, O, 7, RD; 182. **Arctium minus*, O, 7, RD; 758. **Arcensis annua*, U, 7, PP; 1418. **Aster cordifolius*, O, 5, PP; 1628. **A. divaricatus*, O, 5, B; 1415. **A. infirmis*, C, 5, B; RD; 969, 1038. **A. lateriflorus*, O, 5, LW; 1610. **A. patens*, U, 5, S; 1592. **A. paterculus*, O, 5, RD; 717, 1445. **A. pilosus*, C, 5, RD; RD; 1312, 1528. **A. pumilus*, O, 5, RD; 1499. **A. undulatus*, O, 5, RD; 1589. **A. idens aristosa*, C, 5, RD; 1029, 1225. **A. bipinnata*, O, 4, RD; 1236. **A. frondosa*, O, 3, RD; 1448. **A. tripartita*, O, 7, LW; 1366, 1412. **Carduus discolor*, O, 5, RD; 1189. **C. lanceolatus*, O, 7, PP; RD; 1042, 1172. **Centaurea cyamus*, A, 7, RD; 351. **C. nuculosa*, O, 7, RD; 687. **Chrysanthemum leucanthemum*, A, 7, RD; 352. **Chrysogonum virginianum*, U, 5, LW; 94. **Cichorium intybus*, O, 7, RD; 857. **Coleopsis lanceolata*, C, 5, RD; 387, 469. **C. verticillata*, C, 5, RD; 489. **Colpitis alba*, O, 6, PP; 1289. **Elephantopus carolinianus*, O, 4, RD; 1015. **E. tomentosus*, C, 5, LW; 912. **Erechtites hieracifolia*, O, 5, RD; 1392. **Eriogonum annuus*, C, 3, B; RD; 353, 475. **E. canadensis* var. *canadensis*, A, 4, RD; 1199, 1391. ****E. philadelphicus*, U, 5, PP; 329. **E. strigosus*, C, 5, RD; 605. **Eupatorium album*, U, 5, RD; 1381. **E. capillifolium*, O, 5, RD; 1560. **E. coelestinum*, C, 5, RD; 1371. **E. fistulosum*, C, 5, RD; 1013, 1358. **E. hyssopifolium*, C, 5, RD; 1439. **E. perfoliatum*, O, 5, LW; 1213. **E. purpureum*, O, 5, B; 750. **E. rotundifolium*, U, 5, RD; 1037, 1336. **E. rugosum*, O, 5, LW; 1423. **E. sessilifolium*, O, 5, LW; 1150. **Galinsoga ciliata*, O, 7, PP; 799. **Gnaphalium obtusifolium*, C, 5, RD; 1328. **G. purpureum*, C, 4, RD; 262. **Helenium flexuosum*, U, 5, RD; 1636. ****Heliopsis annuus*, O, 5, RD; 945. **H. atrorubens*, O, 5, RD; 1158. **H. decapetalus*, O, 5, LW; 1307. ****H. mollis*, C, 5, S; 1594. **H. strumosus*, O, 5, RD; 1265, 1387. **H. tuberosus*, O, 5, RD; 1183. **Heterotheca mariana*, O, 5, RD; 1134. **Hieracium Gronovii*, O, 5, RD; 1315, 1386. **H. scabrum*, U, 5, RD; 1239. **H. venosum*, O, 5, RD; 174, 868. **Hypochaeris radicata*, C, 7, RD; 235. **Erigia virginica*, O, 5, RD; 159. **Lactuca canadensis*, C, 3, RD; 824. **L. floridana*, O, 5, LW; 1137. **L. scariola*, O, 5, RD; 1204. **Liatris squarrosa*, C, 5, RD; 927, 1132. **Mikania scandens*, O, 5, B; RD; 1123. **Parthenium integrifolium*, U, 5, RD; 412. **Polymnia uvedalia*, A, 5, LW; 951. **Prenanthes altissima*, O, 5, LW; 1598. **P. sergentiana*, O, 5, RD; 1329, 1590. **Pyropappus carolinianus*, O, 5, RD; 615. **Rudbeckia hirta*, C, 4, S; 754. **R. laciniata*, O, 5, LW; 1257, 1371. **R. triloba*, U, 5, RD; 943. **Senecio aureus*, A, 5, LW; 134. **S. obtusatus*, U, 5, B; 202. **S. smallii*, C, 5, RD; 377. **Silphium trifoliatum*, U, 5, RD; 944. **Solidago altissima*, A, 5, RD; LW; 1576, 1607. **S. bicolor*, O, 5, B; RD; 891, 1444. **S. caesia*, O, 5, RD; 1519. **S. erecta*, O, 5, RD; LW; 1471, 1555. **S. gigantea*, O, 5, B; 1283. **S. graminifolia*, O, 5, RD; 1319, 1496. **S. juncea*, C, 5, PP; 968. **S. nemoralis*, A, 5, RD; 1393, 1595. **S. odora*, O, 5, RD; 1332. **S. pinnatum*, A, 5, S; 1009, 1318. **S. rugosa*, O, 5, RD; RD; 1493, 1622. **Sonchus asper*, O, 7, RD; 470. **Taraxacum officinale*, C, 7, RD; 1634. **Verbena alternifolia*, A, 5, PP; 804, 965. **V. occidentalis*, C, 5, LW; RD; 925, 1273. **Veronica glauca*, O, 5, RD; 928, 1275. **V. noveboracensis*, O, 5, LW; 1208. **Wurmbia strumarum*, O, 7, PP; 1544.

BALSAMINACEAE: **Impatiens capensis*, A, 5, PP; 1164. **I. pallida*, C, 5, PP; 791.

BERBERIDACEAE: **Jeffersonia diphylla*, O, 5, LW; 293. **Podophyllum peltatum*, A, 5, LW; 209.

BETULACEAE: **Alnus serrulata*, C, 5, LW; 1069, 1211. **Betula nigra*, O, 5, LW; 1071. **Carpinus caroliniana*, C, 5, LW; 407, 1547. **Corylus americana*, O, 5, LW; 1464, 1480. **Ostrya virginiana*, U, 5, B; 363.

BIGNONIACEAE: **Campsis radicans*, C, 5, RD; 692.

BORAGINACEAE: **Cynoglossum virginianum*, U, 5, LW; 311. **Echium vulgare*, U, 7, RD; 1121. **Hakelia virginiana*, U, 5, LW; 1274. **Lithospermum*

arvense, O, 7, RD; 98, 397. **Myosotis macrosperma*, A, 5, LW; 308. **M. verna*, O, 4, RD; 252b.

BRASSICACEAE: **Alliaria petiolata*, C, 7, RD; 169. **Arabisopsis thaliana*, C, 7, RD; 71. **Arabis canadensis*, U, 5, LW; 488. **A. laevigata*, U, 5, LW; 118. **Barbarea verna*, C, 7, RD; 103. **B. vulgaris*, O, 7, RD; 170. **Brassica napus*, C, 7, RD; 101. **Capella bursa-pastoris*, C, 7, RD; PP; 33, 330. **Cardamine bulbosa*, O, 5, LW; 213. **C. conconata*, A, 5, LW; B; 21, 36. **C. hirsuta*, A, 7, PP; RD; 25, 34. **C. parviflora* var. *arenicola*, U, 1, RD; 160. **Draba verna*, C, 7, RD; 32. **Erysimum cheiranthoides*, C, 1, PP; 540, 1537. **Lepidium campestre*, O, 7, RD; 138, 268. **L. virginicum*, O, 3, RD; 255. **Raphanus raphanistrum*, O, 7, RD; 335. **Rorippa islandica*, O, 1, PP; 895. **Sisymbrium officinale* var. *leiocarpum*, O, 7, PP; 269, 281. ****Teesdalia media*, O, 7, RD; 403. **Thlaspi arvense*, O, 7, RD; 102, 391. **T. perfoliatum*, A, 7, RD; 74.

CACTACEAE: **Opuntia compressa*, A, 5, RD; 1373.

CALLITRICHACEAE: **Callitriche heterophylla*, C, 4, RD; 93, 133.

CAMPANULACEAE: **Isobelia cardinalis*, U, 5, LW; 987. **I. inflata*, O, 5, PP; 893. **M. puberula*, U, 5, RD; 1375. **M. siphilitica*, U, 5, PP; 1282. **M. spicata*, O, 5, LW; 649. ****Specularia biflora*, U, 4, RD; 537. **S. perfoliata*, A, 4, RD; 417.

CANNABACEAE: **Humulus japonicus*, A, 7, PP; 1294.

CAPRIFOLIACEAE: **Lonicera japonica*, A, 7, RD; 481. **Sambucus canadensis*,

O, 4, LW; 522. **Symphoricarpos orbiculatus*, O, 5, LW; LW; 166, 793.

**Trielostem perfoliatum*, O, 5, S; 755. **Viburnum acerifolium*, O, 5, LW;

485. **M. dentatum*, C, 5, LW; LW; 359, 1143. **V. nudum*, O, 5, LW; 737.

**V. prunifolium*, U, 5, RD; B; 53, 128.

CARYOPHYLLACEAE: **Agrostemma githago*, O, 7, RD; 478. **Arenaria groenlandica* var. *glabra*, A, 5, RD; 124, 196. **A. sarrhyllifolia*, C, 7, RD; RD; 538, 623. **Cerastium glomeratum*, C, 7, RD; 69. **Dianthus ameria*, O, 7, RD; 364. **D. prolifer*, U, 7, RD; 1103, 1356. **Holosteum umbellatum*, A, 7, RD; 79. **Lychnis alba*, O, 7, RD; RD; 389, 425. ****L. coronaria*, U, 7, RD; 693. **Sagina dumetorum*, O, 5, RD; 216. **Saponaria officinalis*, O, 7, RD; 821. **Scleranthus annuus*, O, 7, RD; 432. **Silene antirrhina*, O, 7, RD; 392. **S. caroliniana*, O, 5, RD; 186. **S. cucubalus*, O, 7, RD; 406, 1135. **S. stellata*, O, 5, B; 890. **Stellaria media*, A, 7, RD; 1632. **S. pubera*, C, 5, B; 22, 556.

CELASTRACEAE: **Euonymus americanus*, O, 5, B; 296.

CHENOPODIACEAE: **Chenopodium album*, C, 7, RD; LW; 808, 1361. **C.*

ambrosioides, C, 7, RD; 1442, 1510.

CISTACEAE: ****Lechea intermedia*, U, 5, RD; 1030b. **L. racemulosa*, O, 5, RD; 1161, 1588. **L. tenuifolia*, U, 5, RD; 1010b.

CONVOLVULACEAE: **Calystegia sepium*, O, 1, RD; 554, 1186. ****Cuscuta campestris*, C, 4, RD; 926. **C. compacta*, O, 5, LW; 1485. **C. Gronovii*, C, 5, LW; 1173, 1420. **Ipomoea racemosa*, O, 7, RD; 956, 1195. **I. lacunosa*, O, 5, RD; 1226. **I. pandurata*, O, 5, RD; 859. **I. purpurea*, O, 7, RD; 1229, 1433.

COMBACEAE: **Cornus amomum*, U, 7, RD; 647, 1073. **C. florida*, C, 4, LW; 107.

CRASSULACEAE: **Penthorum sedoides*, O, 5, LW; 1149, 1466. ****Sedum*

sarmentosum, A, 7, RD; 454. **S. ternatum*, A, 5, B; 219.

CUCURBITACEAE: **Sicyos angulatus*, U, 5, B; 1411.

EBENACEAE: **Diospyros virginiana*, O, 5, LW; 521.

ELAEAGNACEAE: ****Elaeagnus umbellata*, O, 5, LW; 1036.

ERICACEAE: **Chimaphila maculata*, C, 5, LW; 724. **C. umbellata*, O, 1,

LW; 586. **Gaultheria hirsuta*, U, 5, RD; 271, 525. **Malina latifolia*, U, 5, LW; 1259. **Leucothoe racemosa*, O, 5, LW; 420, 644. **Monotropa hypophyllum*, U, 4, LW; 656. **M. uniflora*, O, 2, LW; 837. **Oxycodendrum arboreum*, O, 5, LW; 739. **Pyrola rotundifolia* var. *americana*, U, 1, LW; 636. **Rhododendron nudiflorum*, O, 5, B; LW; 184, 192. **Vaccinium atrococcum*, O, 5, LW; 96. **V. stramineum*, U, 5, LW; 208, 250. **V. vacillans*, O, 5, RD; LW; 147, 527.

- EUPHORBACEAE: **Acalypha gracilens*, O, 5, RD; 1509, 1562. **A. rhomboides*, O, 5, RD; 1288, 1500. **Croton glandulosus* var. *septentrionalis*, O, 5, RD; 1163. **Crotonopsis elliptica*, O, 5, RD; 1094. *Euphorbia corollata*, C, 5, RD; 322, 608. **E. cyparissias*, O, 7, RD; 75. **E. nuda*, O, 4, RD; 1018, 1311. ***E. obtusata*, U, 5, LM; 501.
- FABACEAE: **Albisia julibrissin*, O, 7, RD; 685. **Amphicarpa bracteata*, O, 5, LM; 1246, 1477. **Apios americana*, C, 5, LM; 1074. **Baptisia tinctoria*, O, 5, RD; 514. **Cassia fasciculata*, O, 5, RD; 1119, 1337. **C. marilandica*, O, 5, FP; RD; 953, 1551. **C. nictitans*, O, 5, RD; LM; 995, 1049. **Centrosema virginianum*, U, 5, RD; 1267. **Cercis canadensis*, C, 4, LM; 1422. *Clitoria mariana*, O, 5, RD; LM; 822, 1162. ****Crotalaria macronota*, U, 7, RD; 1518. **Cytinus scoparius*, 3, 7, U; 167. **Desmodium canadense*, O, 5, RD; LM; 960, 1016. **D. labellum*, O, 5, LM; RD; 999, 1053. ****D. glutinosum*, O, 4, LM; 771. **D. marilandicum*, O, 5, LM; 1362. **D. nudiflorum*, O, 5, LM; 828, 1087. **D. paniculatum*, O, 5, S; 1321. **D. petendifolium*, O, 5, RD; 1376. **Galactia volubilis*, O, 5, LM; 957. **Gleditsia triacanthos*, O, 5, RD; 1570. **Lathyrus hirsutus*, O, 5, FP; 559. **Lespedeza cuneata*, O, 7, RD; 1269. **L. procumbens*, O, 5, LM; 1222. *L. repens*, O, 5, RD; 480, 1334. **L. stipulaceus*, O, 7, RD; 1344. **L. striate*, O, 7, RD; 1341b. **L. virginica*, O, 5, RD; 1035, 1338. **Medicago lupulina*, C, 7, RD; 596. ****M. sativa*, C, 7, RD; 415. **Heliotropium alba*, O, 7, RD; 471. **M. officinalis*, C, 7, RD; 413. **Thaeria lobata*, A, 7, RD; 1233. **Robinia pseudo-acacia*, O, 5, LM; 275. **Stylosanthes biflora*, O, 5, RD; 858. **Tephrosia virginiana*, C, 5, RD; 376. **Trifolium arvense*, C, 7, RD; 414. **T. campestre*, C, 7, RD; 370, 628. **T. dubium*, C, 7, RD; 253. 437. **T. pratense*, C, 7, RD; 354. **T. repens*, A, 7, RD; 369. **Vicia angustifolia*, C, 7, RD; 350. **M. dasycarpa*, C, 7, RD; 254, 400. **V. hirsuta*, O, 7, FP; LM; 236, 361.
- FAGACEAE: ***Castanea dentata*, U, 5, LM; 941. **C. pumila*, O, 5, LM; 686. **Fagus grandifolia*, A, 5, LM; 1532. **Quercus alba*, A, 5, LM; 1556. **Q. coccinea*, C, 5, LM; 1429, 1559. **Q. falcata* var. *falcata*, O, 5, LM; 1557. **Q. marilandica*, O, 5, LM; 1428. **Q. phellos*, O, 5, LM; 510. **Q. prinus*, C, 5, LM; 1403, 1446. **Q. rubra*, O, 5, LM; 1553. **Q. stellata*, O, 5, LM; 1280, 1558. **Q. velutina*, O, 5, LM; 1460.
- FUMARIACEAE: **Corydalis flavula*, C, 5, B, LM; 50, 63. **Dicentra canadensis*, A, 5, S, LM; 51, 109.
- GENTIANACEAE: **Gentiana villosa*, O, 5, LM; 1491. **Obolaria virginica*, R, 5, LM; 503. **Sabatia angularis*, O, 5, LM; 1256.
- GERANIACEAE: **Geranium carolinianum*, O, 3, RD; 270. **G. maculatum*, U, 5, LM; 384. **G. molle*, O, 7, RD; 283, 64.
- RAMNULACEAE: **Liquidambar styraciflua*, C, 4, LM; 1431.
- HYDROPHYLLACEAE: ***Elisia nyctelae*, A, 5, FP; 288. ****Hydrophyllum canadense*, A, 5, FP; 797. **Nemophila microcalyx*, C, 5, FP; 29, 38. **Phacelia dubia*, O, 5, RD; 193.
- HYPERICACEAE: **Hypericum gentianoides*, O, 5, RD; 865, 876. **H. hypericoides*, O, 4, RD; 922. **H. mutuum*, O, 5, RD; 867. **H. perforatum*, O, 7, RD; 820. **H. prolificum*, U, 5, S; 888. **H. punctatum*, O, 5, LM; RD; 768, 855. ****H. stragalum*, O, 5, RD; 829. ****H. virginicum*, O, 5, RD; 1136. ****H. walteri*, O, 5, LM; 1062.
- JUGLANDACEAE: **Carya cordiformis*, O, 5, LM; 1456. **C. ovalis*, C, 5, LM; 1591. **C. tomentosa*, C, 5, LM; 1437, 1568. **Juglans nigra*, C, 5, RD; 1563.
- LAMIACEAE: **Agastache nepetoides*, U, 5, LM; 1426. ****Juga reptans*, U, 7, RD; 141. **Collinsonia canadensis*, U, 5, S; 1404. **Conium maculatum*, C, 5, RD; 1180. **Cleome hederacea*, O, 7, FP; 48. **Hedeoma pulegioides*, O, 5, RD; 1040. ****Isanthus brachiatus*, O, 5, RD; 1169, 1425. **Lamium amplexicaule*, A, 7, RD; 13. **L. purpureum*, U, 7, FP; 41. **Lycopus americanus*, C, 3, FP; 966. **Urtica virginica*, O, 5, LM; 1076. ****Marrubium vulgare*, C, 7, RD; 280. ****Monarda fistulosa*, O, 4, S; 757, 904. **Perilla frutescens*, C, 7, LM; 1419. **Prunella vulgaris*, C, 1, RD; 740. **Pycnanthemum incanum*, O, 5, RD; 1014. **P. tenuifolium*, O, 5, RD; 1131. *Salvia lyrata*, C, 5, LM; 259. **Stachys calamintha* var. *neptata*, O, 7, RD; 763, 1629. **S. vulgaris*, O, 7, LM; RD; 825, 903.
- **Scutellaria elliptica*, O, 5, FP; 549. **S. integrifolia*, O, 5, RD; LM; 714. 716. **S. lateriflora*, O, 3, LM; 1001. ****S. ovata*, O, 4, S; 563. **Teucrium canadense*, O, 3, RD; 902. **Trichostema dichotomum*, C, 5, RD; 1323.
- LAURACEAE: **Lindera benzoin*, C, 5, LM; 1479. **Sassafras albidum*, C, 5, LM; 1571.
- LENTIBULARIACEAE: ***Utricularia biflora*, U, 5, AQ; 1067.
- LINACEAE: **Linum striatum*, O, 5, RD; 916. *L. virginicum*, O, 5, RD; 1017.
- LOGANIACEAE: **Polypremum procumbens*, O, 4, RD; RD; 874, 1327.
- LOXANTHACEAE: **Phoradendron serotinum*, U, 5, LM; 1633.
- MAGNOLIACEAE: **Liriodendron tulipifera*, C, 5, LM; 303. ****Magnolia virginiana*, U, 5, LM; 73.
- MALYACEAE: ***Abutilon theophrasti*, O, 7, RD; 1159. **Hibiscus moscheutos*, C, 5, LM; 1072. **H. syriacus*, O, 7, RD; 1245. **Malva neglecta*, C, 7, RD; 282. **Sida spinosa*, O, 7, RD; LM; 1005, 1197.
- MELASTOMACEAE: **Rhexia mariana*, C, 5, RD; 774, 1322.
- MENISPERMACEAE: **Menispermum canadense*, U, 5, S; 191.
- MORACEAE: **Morus rubra*, O, 5, LM; 474.
- MYRTACEAE: **Nuphar luteum*, A, 4, AQ; 726. **Nymphaea odorata*, O, 4, AQ; 731.
- NYSSACEAE: **Nyssa sylvatica*, O, 5, LM; 736.
- OLEACEAE: **Chionanthus virginicus*, O, 5, S; 534. **Fraxinus pennsylvanica*, O, 5, LM; 557. ****Ligustrum obtusifolium*, C, 7, LM; RD; 347, 360. **L. sinense*, O, 7, RD; 409.
- ONAGRACEAE: **Circaea lutetiana* ssp. *canadensis*, C, 1, LM; 850. **Epilobium coloratum*, O, 5, FP; RD; 1032, 1178. **Gaura biennis*, O, 5, RD; 1572. **Ludwigia alternifolia*, C, 5, RD; RD; 961, 1259. **M. decurrens*, O, 4, RD; 1271. **L. palustris*, O, 4, AQ; 696. **Oenothera biennis*, O, 4, RD; 975, 1238. **O. laevis*, O, 4, RD; 399, 455.
- OROBANCHACEAE: **Conopogon americana*, C, 5, S; 609. **Epipogon virginiana*, O, 5, S; 3, 1279. **Orobancha uniflora*, R, 3, S; 223.
- OXALIDACEAE: **Oxalis dillenii*, O, 4, RD; 1022. ****O. florida*, O, 5, LM; 670. **O. stricta*, O, 4, RD; 993. **O. violacea*, U, 5, LM; 240.
- PAPAVERACEAE: **Papaver dubium*, O, 7, RD; 402. **Sanguinaria canadensis*, C, 5, S; 18.
- PASSIFLORACEAE: **Passiflora incarnata*, U, 5, RD; 906. **P. lutea*, O, 5, RD; 1190.
- PHRYNACEAE: **Phryma leptostachya*, O, 2, LM; 775.
- PHYTOLACACEAE: **Phytolacca americana*, C, 5, RD; 528.
- PLANTAGINACEAE: **Plantago aristata*, C, 3, RD; 463. *P. lanceolata*, C, 7, RD; 274. **P. rugelii*, C, 5, RD; 762. **P. virginica*, C, 5, RD; 146.
- PLATANACEAE: **Platanus occidentalis*, O, 5, LM; 1192.
- POLKONIACEAE: **Phlox divaricata*, A, 5, LM; 228. **P. subulata*, O, 5, RD; 88, 162.
- POLYGONACEAE: ****Polygona mariana*, U, 5, RD; 1374, 1447.
- POLYGNOMACEAE: **Polygamm arifolium*, C, 5, LM; 1214, 1484. ****P. aviculare*, C, 7, RD; 536, 811. ****P. cephalosum* var. *longisetum*, C, 7, FP; 1293, 1539. **P. convolvulus*, O, 7, RD; 810, 1348. **P. hydrophyllum*, O, 7, LM; 1210c. **P. hydro-piperoides*, O, 4, LM; 1272a. **P. lapathifolium*, O, 6, FP; 1296. **P. pensylvanicum*, O, 5, FP; LM; 1079, 1292. **P. persicaria*, O, 7, RD; 655. ****P. punctatum*, C, 4, FP; LM; 878, 1286. **P. sagittatum*, A, 5, LM; 1483. **P. setaceum*, O, 5, LM; RD; 847, 998. **Rumex acetosella*, O, 7, RD; RD; 145, 451. **R. crispus*, C, 7, FP; 570. **R. obtusifolius*, O, 7, FP; LM; 803, 896. **Tovara virginiana*, U, 2, LM; 882.
- PORTULACACEAE: **Claytonia virginica*, A, 5, LM; 11. **Portulaca grandiflora*, U, 7, RD; 1529. **P. oleracea*, O, 7, RD; 1531. **Talinum teretifolium*, C, 5, FP; 530.
- PREMILLACEAE: **Anagallis arvensis*, U, 7, RD; 473. **Lysimachia ciliata*, O, 5, FP; LM; 572, 676. **L. quadrifolia*, O, 5, S, RD; 349, 568. ***L. terrestris*, U, 5, LM; 660.
- RANUNCULACEAE: **Aconitum uncinatum*, U, 5, LM; 648. **Anemone virginiana*,

O, 5, UW; 777. **Cisticfuga racemosa*, C, 5, UW; 770. *Clematis ochroleuca*, U, 5, RD; 1W, 249, 247. **C. virginiana*, O, 5, UW; 1204. **Delphinium ajacis*, C, 7, RD; 279. **Hepatica americana*, U, 5, UW; 2. **Ranunculus abortivus*, O, 3, 1W, RD; 72, 197. **R. bulbosus*, O, 7, RD; 175. **R. hispidus*, O, 5, UW; 171. ***R. micranthus*, A, 5, UW; 229. ***R. parviflorus*, U, 7, RD; 163. **R. pusillus*. ROSACEAE: **Aerionia parviflora*, O, 4, FP, UW; 967, 1258. **A. pubescens*, O, 5, UW; 832, 901. **A. rostellata*, O, 5, UW; 884. **Amelanchier arborea*, U, 5, UW, RD; 59, 189. **Duchesnea indica*, C, 7, RD; 420. **Fragaria virginiana*, O, 5, RD; 89. **Geum canadense*, O, 5, UW; 738, 779. **G. virginianum*, U, 5, UW; 778. **Potentilla canadensis*, C, 5, UW, UW; 91, 246. **P. norvegica*, U, 1, RD; 701. **P. recta*, O, 7, RD; 404. **Prunus avium*, U, 7, UW; 116. **P. hortulana*, O, 5, UW; 76. ***P. persica*, U, 7, UW; 77. **P. serotina*, C, 4, RD; 183. ***Pyrus communis*, U, 7, RD; 68. **Rosa caroliniana*, O, 5, RD; 416, 460. **R. multiflora*, O, 7, FP; 337b. **R. palustris*, O, 5, UW; 733. **R. wichuriana*, O, 7, RD; 508. **Rubus allegheniensis*, O, 5, FP; 292, 346. **R. flagellaris*, U, 5, UW; 148. **R. occidentalis*, O, 5, UW; 476, 611. RUBIACEAE: **Opalanthus occidentalis*, O, 4, UW; 720, 845. **Diodia ceras*, O, 5, RD; 864, 1026. *D. virginiana*, C, 5, RD; 962, 1117. **Galium aparine*, A, 1, UW; 339, 582. **G. circoceras*, C, 5, UW; 591, 784. **G. obtusum*, C, 5, UW; 484. **G. pilosum*, C, 5, UW; 917, 952. **G. cinctorum*, O, 3, UW; 718, 1050. **G. triflorum*, O, 1, FP, UW; 827, 1284. **Monotonia caerulea*, O, 5, B; 55. **H. longifolia*, O, 5, UW; 782. **H. purpurea*, C, 5, UW; 302. **Mitchella repens*, C, 5, UW; 80. ***Sherardia arvensis*, C, 7, RD; 531. SALTICACEAE: ***Populus alba*, O, 7, RD; 516. **P. deltoides*, O, 5, RD; 654. ***P. grandidentata*, O, 5, UW; 526. ***Salix nigra*, C, 5, RD; 1635. SAURURACEAE: *Saururus cernuus*, A, 5, UW; 664. SAXIFRAGACEAE: ***Chrysosplenium americanum*, C, 5, UW; 82. **Heuchera americana*, O, 5, UW; 296. **Hydrangea arborescens*, O, 5, B; 566. **Vitis virginica*, O, 5, UW; 643, 1070. ***Phladelphus inodorus*, O, 5, RD; 477. **Saxifraga virginiana*, C, 5, B; 31. SCROPHULARIACEAE: **Agalinis purpurea*, U, 4, RD; 1505. **Aureolaria*

pedicularis, O, 5, RD; 1179. **A. virginica*, O, 5, RD; 694. **Chelone glabra*, O, 5, AQ; 1526. **Crotalaria neglecta*, O, 5, UW; 578. **C. pilosa*, O, 5, RD; 1241. **C. virginiana*, O, 5, AQ; 421. **C. viscidula*, O, 5, UW; 634, 1147. **Xickia elatine*, R, 7, RD; 805. **Linaria canadensis*, O, 4, RD; 194, 329. **Lindernia dubia*, O, 4, AQ; 1056, 1306. **Timulus alatus*, O, 5, UW; 1058. **Paulownia tomentosa*, O, 7, UW; 108. **Penstemon canescens*, O, 5, RD; 422, 461. **Scrophularia barilandica*, C, 5, UW; 1550. *Verbascum blattaria*, U, 7, RD; 472. **V. thapsus*, C, 7, RD; 1122. ****Veronica agrestis*, U, 7, RD; 195. **V. arvensis*, C, 7, RD; 104. **V. hederifolia*, O, 7, FP; 28. **V. officinalis*, O, 7, UW; 577. **V. pemptina*, A, 4, RD; 106, 393. SIMARUBACEAE: **Allanthus altissima*, C, 7, UW; 1430. SOLANACEAE: **Datura stramonium*, O, 7, RD; 1027. **Lycium halimifolium*, U, 7, RD; 1506. **Physalis virginiana*, O, 5, RD; UW; 669, 1168. **Solanum americanum*, U, 5, FP; 1541. **S. carolinense*, C, 5, RD; 372. STAPHYLEACEAE: **Staphylea trifolia*, O, 5, UW; 573. TILIACEAE: **Tilia americana*, U, 5, UW; 285. UMBELLACEAE: **Celtis occidentalis*, O, 5, RD; 873. **Ulmus alata*, U, 5, UW; 244. **U. americana*, O, 5, FP; 56. **U. rubra*, O, 5, UW; 14. URTIACEAE: **Boehmeria cylindrica*, O, 4, UW; 848. **Laportea canadensis*, A, 5, FP; 1176. **Pilea pumila*, O, 5, UW; 1577. VALERIANACEAE: **Valerianaella lacustris*, C, 7, RD; 199, 252. **V. umbellata*, O, 5, RD; 252a. VERBENACEAE: **Verbena urticifolia*, O, 5, UW; 749. VIOLACEAE: **Viola affinis*, C, 5, UW; 140. **V. arvensis*, U, 7, S; 652. **V. cucullata*, C, 5, UW; 233, 241. **V. eriocarpa* var. *leiocarpa*, A, 5, UW; 37, 110. **V. fimbriatula*, C, 5, RD; 40, 149. **V. palmaria* var. *palmaria*, C, 5, UW; 242. **V. palmaria* var. *sororia*, O, 5, RD; 187. **V. palmaria* var. *triloba*, U, 5, RD; 154. **V. graminifolia*, C, 5, RD; 157. **V. rafinesquii*, C, 7, RD; 35, 100. **V. sagittata*, C, 5, RD; 153, 158. **V. striata*, C, 5, FP; 224. VITACEAE: **Parthenocissus quinquefolia*, A, 4, RD; 424. **Vitis aestivalis*, O, 5, UW; 458. **V. bailyana*, O, 5, B; 286. **V. cinerea*, O, 5, UW; 520. **V. labrusca*, O, 5, RD; 453. **V. rotundifolia*, O, 5, UW; 1325. **V. vulpina*, A, 5, UW; 798.

Literature Cited

- Allard, H. A. and E. C. Leonard. 1943. The vegetation and floristics of Bull Run Mountain, Virginia. *Castanea* 8: 1-64.
- _____. 1944. Additions to the flora of Bull Run Mountain, Virginia. *Castanea* 9: 130-134.
- _____. 1952. The vegetation and flora of Bull Run Mountain, Virginia. *Castanea* 17: 145-157.
- _____. 1962. List of vascular plants of the northern Triassic area of Virginia. *Castanea* 27: 1-56.
- Bailey, L. H. 1949. Manual of cultivated plants. The MacMillan Company, New York. 1116 pp.
- Berg, J. D. 1974. Vegetation and succession on Piedmont granitic outcrops of Virginia. Unpublished M.A. thesis, College of William and Mary, Williamsburg, Virginia. 74 pp.
- Boule, M. F. 1979. The vegetation of Fisherman Island, Virginia. *Castanea* 44: 99-108.
- Bradley, T. R. 1972. Plant records for northern Virginia and State. *Castanea* 37: 49-59.
- Crow, G. E. 1978. A taxonomic revision of *Sagina* (Caryophyllaceae) in North America. *Rhodora* 80: 1-91.
- Diggs, G. M., Jr. and G. W. Hall 1981. Vascular flora and vegetation of the Kent Branch Watershed, Fluvanna County, Virginia. *Virginia J. Sci.* 32 (1): 23-33.
- Duncan, W. H. 1967. Woody vines of the southeastern states. *Sida* 3: 1-76.
- Fenneman, N. M. 1938. Physiography of Eastern United States. McGraw Hill, New York. 714 pp.
- Fernald, M. L. 1950. Gray's manual of botany, eighth edition. American Book Company, New York. 1632 pp.
- Gleason, H. A. 1952. The new Britton and Brown illustrated flora of the northeast United States and adjacent Canada. Lancaster Press Incorporated, Lancaster, Pennsylvania. 3v.
- Gleason, H. A. and A. Cronquist. 1963. Manual of vascular plants of northeastern United States and adjacent Canada. Van Nostrand Reinhold Company, New York. 810 pp.
- Gould F. W. 1975. The grasses of Texas. Texas A & M University Press, College Station, Texas. 653 pp.
- Harvill, A. M., Jr. 1965. The plant element in the flora of the Peninsula of Virginia. *Rhodora* 67: 393-398.
- _____. 1967. Some noteworthy plants of Virginia. *Castanea* 32: 185-186.
- _____. 1969a. *Isotria medeoloides* on the Piedmont of Virginia. *Rhodora* 71: 303-304.
- _____. 1969b. Virginia species with disjunct populations in the Middle West. *Castanea* 34: 225-229.
- _____. 1972. The historical significance of some disjunct distributional patterns in Virginia. *Castanea* 37: 137-140.
- _____. 1973a. Some new and very local populations of rare species in Virginia. *Castanea* 38: 305-307.
- _____. 1973b. Phytogeography of the Carices of Virginia. *Rhodora* 75: 248-257.

- _____. 1973c. Phytogeography of the Virginias and the equilibrium concept of landscape. *Castanea* 38: 266-268.
- _____. 1975. Disjunct populations and the antiquity of species. *Castanea* 40: 1-3.
- _____. 1979. Origins and relationships of the flora of southwestern Virginia. *Castanea* 44: 87-91.
- _____, et al. 1977. Atlas of the Virginia flora, part one. Pteridophytes through Monocotyledons. Virginia Botanical Associates, Farmville, Virginia. 59 pp.
- Hathaway, W. T. and G. W. Ramsey. 1973. The flora of Pittsylvania County, Virginia. *Castanea* 38: 38-78.
- Hill, L. M. 1980. The genus *Aster* (Asteraceae) in Virginia. *Castanea* 45: 104-124.
- Hitchcock, A. S. 1950. Manual of the grasses of the United States, 2nd edition, revised by Agnes Chase. U.S. Dept. of Agriculture, Miscellaneous Publication no. 200. Government Printing Office, Washington, D.C. 1051 pp.
- Hult  n, E. 1937. Outline of the history of the Arctic and Boreal biota during the Quaternary Period. Wheldon and Wesley, Ltd., New York. 201 pp.
- _____. 1958. The Amphi-Atlantic plants. Almqvist and Wiksell, Stockholm. 340 pp.
- Hunt, C. B. 1972. Geology of soils. W. H. Freeman and Company, San Francisco. 344 pp.
- Johnson, M. F. 1970. Additions to the flora of Virginia. *Castanea* 35: 144-149.
- _____. 1971a. The genus *Liatris* in Virginia. *Castanea* 36: 137-147.
- _____. 1971b. The genera *Carphephorus*, *Mikania*, and *Kuhnia* (Eupatoriaceae-Asteraceae) in Virginia. *Virginia J. Sci.* 22: 38-41.
- _____. 1972a. Records preliminary to a flora of Virginia. *Castanea* 37: 235-240.
- _____. 1972b. Eupatoriaceae (Asteraceae) in Virginia: *Eupatoriadelphus*, *Ageratina*, *Fleischmannia*, and *Conoclinium*. *Virginia J. Sci.* 23: 48-55.
- _____. 1974a. Eupatoriaceae (Asteraceae) in Virginia: *Eupatorium* I., *Castanea* 39: 205-228.
- _____. 1974b. Cynareae (Asteraceae) in Virginia: *Aretium*, *Centaurea*, *Cnicus*. *Castanea* 39: 63-73.
- _____. 1974c. Cynareae (Asteraceae) in Virginia: *Cirsium*, *Carduus*, *Onopordium*. *Virginia J. Sci.* 25: 152-160.
- Johnson, M. F. and J. Joosten. 1977. Vernoniaceae (Asteraceae) in Virginia: *Elephantopus* and *Vernonia*. *Castanea* 42: 181-189.
- Kral, R. and P. E. Bostick. 1969. The genus *Rhexia* (Mastomataceae). *Sida* 3: 387-440.
- Lewis, W. H. 1958. The Roses of Virginia and West Virginia. *Castanea* 23: 77-88.
- Li, H. 1971. Floristic relationships between Eastern Asia and Eastern United States. Morris Arboretum, Philadelphia. 60 pp.
- Massey, A. B. 1961. Virginia Flora. Virginia Agricultural Experiment Station Bulletin no. 155. 258 pp.
- Mazzeo, P. M. 1972. The gymnosperms of Virginia: a contribution towards the proposed state flora. *Castanea* 37: 179-195.
- Nessler, C. L. 1976. A systematic survey of the tribe Cichorieae in Virginia. *Castanea* 41: 226-248.
- Parker, R. D. 1977. The woody flora of Presquile, Chesterfield County, Virginia. *Castanea* 42: 8-15.
- Poland, F. B. and L. Glover. 1976. The geology of the rocks along the James River between Sabot and Cedar Point, Virginia. Report prepared for the Orogenic Studies Lab, Department of Geological Sciences, Virginia Polytechnical Institute and State University.
- Radford, A. E. et al. 1968. Manual of the vascular flora of the Carolinas. University of North Carolina Press, Chapel Hill. 1183 pp.
- Ramsey, G. W. 1967. Interesting plants for the Virginia Piedmont. *Castanea* 32: 72.
- Ramsey, G. W. et al. 1969. Plant records for the Virginia Piedmont and state. *Castanea* 34: 199-203.
- Rehder, A. 1940. Manual of cultivated trees and shrubs, 2nd. ed. MacMillan Company, New York. 996 pp.
- Roane, M. K. 1975. Rhododendrons native to Virginia. *Virginia J. Sci.* 26: 6-12.
- Roe, G. F. 1977. Helenieae (Asteraceae) in Virginia. *Castanea* 42: 42-50.
- Shimmers, L. H. 1962. Synopsis of *Collinsonia* (Labiateae). *Sida* 1: 76-83.
- Shure, D. J. and H. L. Ragsdale. 1977. Patterns of primary succession on granite outcrop surfaces. *Ecology* 58: 993-1006.
- Small, J. K. 1933. Manual of the southeastern flora. University of North Carolina Press, Chapel Hill. 1554 pp.
- Smith, E. B. 1976. A biosystematic survey of *Coreopsis* in eastern United States and Canada. *Sida* 6: 123-216.
- Thacker, W. et al. 1968. Plants new for the Virginia Piedmont and state. *Castanea* 33: 135-136.
- U. S. Dept. of Agriculture Soil Conservation Service. 1972. Soil survey of Powhatan County.
- Uttal, L. J. and R. S. Mitchell. 1970. Amendments to the flora of Virginia I. *Castanea* 35: 293-301.
- Watson, T. L. 1907. Mineral resources of Virginia. J. P. Bell Company, Lynchburg, Virginia. 618 pp.
- Woodson, B. R., et al. 1977. Vascular flora of the southeast section of Matoaca District, Chesterfield County, Virginia. *Castanea* 42: 237-243.

Additional Abstracts

Fifty-Ninth Annual Meeting of the Virginia Academy of Science
May 12-15, 1981, Old Dominion University

*The abstracts below were omitted
from the Proceedings issue.*

PETROLOGY OF AN ANDESINE ANORTHOSITE BODY NEAR MONTPELIER, VA. K. L. Bice*, Dept. of Geology, College of William and Mary, Williamsburg, VA 23185.

The mineralogy, textures and chemical composition of an andesine anorthosite near Montpelier, VA. were studied to characterize the intrusive and determine the effects of metamorphism of the body.

The anorthosite body consists of two phases: a coarse, gray nonfoliated anorthosite and a white highly granulated, foliated anorthosite. The essential minerals of the coarse or primary anorthosite were plagioclase (An36), pyroxene, quartz and apatite before later alteration introduced amphibole and chlorite as a pseudomorphic replacement of the pyroxene. The andesine occurs in two textural varieties: antiperthite and myrmekite. Accessory minerals include ilmenite, rutile, garnet, biotite and sphene. The granulated anorthosite is composed of plagioclase (An34), quartz, microcline and biotite.

The anorthosite was probably emplaced in the schist through passive intrusion during the pC. After crystallization the area was subjected to intense regional metamorphism. Granulation and recrystallization of the primary anorthosite produced the granulated anorthosite.

EVALUATION OF PERCOLL AS A STABILIZING MEDIUM FOR VIRUS PLAQUE ASSAY. M. C. Franko, G. R. Bryson, and S. R. Webb. Va. Commonwealth Univ., Richmond, VA 23284.

Agar has been traditionally used as a stabilizing agent in viral plaque assays. Since potential problems with maintenance of critical temperature is required with agar, methyl cellulose is now commonly used as a stabilizing agent. Percoll, a PVP-coated silica preparation, is a new medium for density gradient separation. Since it offers several advantages over agar or methyl cellulose, it was evaluated as an alternative stabilizing agent for plaque assay.

The system chosen for comparison of methyl cellulose and Percoll was Coxsackie virus B4 (CB4) and Monkey kidney (BGM) cells. Methyl cellulose and Percoll were compared for efficiency of plating and plaque size relative to equally viscous and dense solutions. At an equal viscosity of 7.67 cP, methyl cellulose (0.07%) did not restrict diffusion of newly released virions and thus did not produce definitive plaques. At an equal density of 1.115 g/ml., methyl cellulose (0.63%) had the same plaque size and was equally efficient. We concluded that Percoll can be substituted for other stabilizing agents and that it offers several advantages. Percoll has a low viscosity, low osmolality, it is non-toxic, is supplied as a sterile medium which can be resterilized by autoclaving, and has a long shelf life. Its one disadvantage is its cost.

(Supported by NIH Grant RO1-AM21730)

FOSSIL FISH AS PALEOCLIMATIC INDICATORS FOR LATE CENOZOIC SEDIMENTS, WESTERN SNAKE RIVER PLAIN, IDAHO. P. C. Kimmel* Geology Dept., George Mason Univ., Fairfax, VA 22110

Late Miocene and late Pliocene cooling trends can be recognized using changes in fossil fish faunas of the Chalk Hills and Glenns Ferry Formations. The fossil fish inhabited successive freshwater rift lakes in southwest Idaho. Each fish fauna can be divided into a group of warm-water taxa (a catfish, *Ictalurus*; a sunfish, *Archoplites*; and the minnows *Orthodon* and *Mylopharodon*) and a group of cool-water taxa (the salmonids, the sculpins, and the minnows *Acrocheilus* and *Mylocheilus*). These groups are defined using the present distributions and habitats of the closest living relatives. When the relative percentages of these two groups are compared in thirteen collections from seven different stratigraphic levels, they show an increasing dominance of the faunas by cool-water taxa at the end of the Miocene. Deposition then ended for a period of several million years. The lowest collections in the Glenns Ferry Formation are also dominated by cool-water taxa. Somewhat higher a single warm-water dominated fauna is followed by collections containing even more cool-water taxa than before, indicating a strong cooling trend at the end of the Pliocene. These data agree with world-wide cooling trends and are supported by fossil mammal and pollen evidence from the Glenns Ferry Formation.

AN ENZYMIC POTENTIAL FOR ESTABLISHING CYCLIC AMP GRADIENTS DURING PATTERN FORMATION IN *Dictyostelium discoideum*. R. K. Merkle and C. L. Rutherford*, Dept. of Biology, VPI&SU, Blacksburg, VA. 24061. Cyclic AMP is known to function as the chemotactic signal during aggregation of single-celled amoebae of the cellular slime mold *Dictyostelium discoideum*. Evidence from several laboratories has accumulated suggesting that cAMP also acts as a regulatory molecule during *Dictyostelium* multicellular differentiation. We have utilized microtechniques and an ultrasensitive radioimmunoassay in the localization and biochemical analysis of adenylate cyclase, the cAMP synthetic enzyme in order to test for the potential to establish cAMP gradients. Adenylate cyclase activity was localized in the pre-spore cells of the culminating individual with no activity detectable in the pre-stalk region. We found an increasing gradient of activity from the tip of the individual to the base of the spore mass. The same localization was apparent in earlier stages of the life cycle. Adenylate cyclase activity from mass cultures has been characterized. We found that a divalent cation is required for enzyme activity and that with Mn²⁺ the activity is 8-fold greater than with Mg²⁺. Typical mammalian adenylate cyclase modulators, such as Gpp(NH)p and NaF did not activate the *Dictyostelium* enzyme. The adenylate cyclase localization data along with that from 5'AMP nucleotidase and cAMP phosphodiesterase indicate that the potential exists for establishing gradients of the suspected morphogen, cAMP, during pattern formation in *Dictyostelium*.

OBITUARIES

Clyde Y. Kramer

1925 - 1981

Dr. Clyde Y. Kramer, Professor of Statistics, VPI&SU, died June 8, 1981 at the age of 56. On the Virginia Tech faculty since 1951, he became director in 1957 of the Statistical Consulting Laboratory, serving the Agricultural Experiment Station. He served as head of the Department of Statistics during 1972-73, and had been undergraduate coordinator for the Department since 1976. He was widely recognized as one of the nation's outstanding statistical consultants, and his unique teaching abilities were recognized through invitations to teach short courses throughout the United States and in Europe and the Far East. His research publications have been highly acclaimed and widely cited. He was a member of numerous professional societies and had been elected as a Fellow of the American Statistical Association, the International Statistical Institute, and the American Association for the Advancement of Science. He served on the Governor's Committee for the Handicapped, and worked actively with the Virginia Junior Academy of Science, and was a Fellow of the Virginia Academy of Science.

Arthur Ballard Massey

1889 - 1981

Arthur Ballard Massey, Emeritus Professor of Biology, VPI&SU, died at his home in Blacksburg, October 15, 1981. Professor Massey was born at Miller's School, Virginia, on January 10, 1889. He received his B.S. degree in 1909 from North Carolina State College where his father was employed as a botanist. He served as an instructor of Botany at Clemson College from 1910 to 1913 and was an Assistant Professor of Botany at Alabama Polytechnic Institute and the Alabama Agricultural Experiment Station from 1913 to 1918. When he came to Virginia Polytechnic Institute to serve as an Associate Professor of Biology in the Virginia Agricultural Experiment Station. He earned his M.S. degree at VPI in 1928. From 1935 to 1959 he was the Botanist with the VPI Wildlife Unit and in 1956 became Professor of biology. He held these positions until he retired in 1959. Lynchburg College awarded him the honorary D. Sc. in 1956. Professor Massey started accumulating specimens of the state flora when he joined the VPI faculty in 1918 and began to organize a herbarium which by his retirement approached 40,000 specimens. In 1961 the Board of Visitors of VPI located the collection permanently in Derring Hall and named it the Massey Herbarium in his honor. Professor Massey was one of those who were instrumental in the establishment of the Mountain Lake Biological Station and the Virginia Flora Committee of The Virginia Academy of Science, which committee he served as chairman for almost 40 years. He was instrumental along with Drs. Ruskin Freer and R. P. Carroll and others in organizing the botanical journal *Claytonia*, which was the predecessor to the Virginia Journal of Science. Though he was well known for his various articles on Virginia botany in scientific journals, and his booklets on various groups of Virginia plants, such as his guide to ferns of Virginia, his best known work in his 1960 book, *Virginia Flora*, a checklist with notes on distribution by county of over 3500 species and varieties of vascular plants recorded from Virginia. An attendee of Virginia Academy of Science meetings well into his 80's, Professor Massey was an Honorary Life Member of the Academy.

Martha K. Roane

NOTES

NOTES





SMITHSONIAN INSTITUTION LIBRARIES



3 9088 01379 9564